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BULLETIN OF THE RESEARCH COUNCIL OF ISRAEL

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Bull. Res. Counc. of Israel. D. Bot.

(Continuing the activities of the *Palestine Journal of Botany, Jerusalem* and *Rehovot Series*)

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A. Mathematics, Physics and Chemistry
B. Biology and Geology
C. Technology
D. Botany

Section D continues the activities of the PALESTINE JOURNAL OF BOTANY, both the Jerusalem and the Rehovot Series. The Rehovot series was the continuation of the PALESTINE JOURNAL OF BOTANY AND HORTICULTURAL SCIENCE founded by H. R. Oppenheimer in 1935. The Jerusalem Series was published by the staff of the Department of Botany of the Hebrew University in Jerusalem (at that time headed by the late A. Eig) and the Rehovot Series by H. R. Oppenheimer and J. Reichert of the Agricultural Research Station at Rehovot.

The editors of the BULLETIN OF THE RESEARCH COUNCIL OF ISRAEL are now happy to be able to provide a platform which unites the various publications in natural science and technology in Israel. Within this framework we are pleased to continue together with the founders of the PALESTINE JOURNAL OF BOTANY the publication of activities in Botany.

Persons and institutions subscribing to or exchanging with either series of the PALESTINE JOURNAL OF BOTANY will receive Section D of the BULLETIN OF THE RESEARCH COUNCIL OF ISRAEL. The following numbers of the PALESTINE JOURNAL OF BOTANY may be obtained at the Weizmann Science Press, P.O.B. 801, Jerusalem: Rehovot Series, Volume II through VIII; Jerusalem Series, Volume IV through VI.

A GEOBOTANICAL SURVEY OF TRANSJORDAN

NAOMI FEINBRUN and M. ZOHARY

Department of Botany, The Hebrew University of Jerusalem

ABSTRACT

(1) This geobotanical survey is based on several research trips in Transjordan made by the authors.

(2) The main physiographic features of the country under review are described. A map of the soil types and a rainfall map of the area are given.

(3) The country comprises three phytogeographical territories, Mediterranean, Irano-Turanian and Saharo-Sindian. The areas of these territories are shown on the phytogeographical map.

(4) The Mediterranean vegetation consists of forest, Maquis and Batha associations.

(5) The main forest and Maquis associations are: the *Pinus halepensis—Hypericum serpyllifolium* assoc., *Quercus calliprinos—Pistacia palaestina infectorietosum, Quercus calliprinos—Juniperus phoenicea* assoc., *Quercetum ithaburense*. The *Quercus calliprinos—Juniperus phoenicea* association confined to high mountains of Edom is of special interest.

(6) Largest in area among Mediterranean Batha associations is the *Salvia dominica—Ballota undulata* association, represented by several variants. *Poterietum spinosi* is much less common than in Cisjordan.

(7) Several Mediterranean species common in Cisjordan are lacking or very rare in Transjordan, such as *Laurus nobilis, Cercis siliquastrum, Pistacia lentiscus, Salvia triloba*, a. o.

(8) The main Irano-Turanian steppe associations are *Artemisietum herbae-albae* and the *Haloxylon articulatum—Salsola villosa* association.

(9) The main Saharo-Sindian associations are variants of *Anabasidetum articulati* on stony Hammadas and on Nubian sandstone, and several associations on granite sand. such as *Haloxyletum persici* and *H. salicornici*.

(10) Enclaves of arboreal Sudanian vegetation are found along the Jordan Valley Rift.

(11) The distribution of the main vegetation types is summarized on the Vegetation Map.

INTRODUCTION

This survey is based mainly on material and data collected by the authors on a research trip in Transjordan in summer 1942. Previously the authors participated in several botanical trips to Transjordan together with the late Prof. A. Eig of the Hebrew University. Data on the distribution of plants and especially of forest trees were completed with the aid of maps and publications by Schumacher (1886, 1920), the diaries of Aaronsohn (1904—08) and other sources (Hart 1891, Tristram 1873). Vegetation transects of some parts of Transjordan by Eig (1946, p. 240—243) were also used.

The itinerary of the above cited trips across Transjordan was as follows:

Received July 5, 1955.

April 1927: Allenby Bridge—es Salt—'Amman—es Sahab—el Kharani—'Amman—es Suweilih—Majdal—Jarash—Irbid—Jisr Majame.

April 1929 and March 1936: Allenby Bridge—'Amman—Ma'an—Petra—Ma'an—'Aqaba.

July 1933: Allenby Bridge—'Amman—Zarqa—Qasr el Azraq.

July 1942: Allenby Bridge—'Amman—Madaba—Mt. Nebo (Har Nevo)—Madaba—Dhiban—Khan ez Zabub—Qatrane—Karak—Rabbat Moav—Karak—Tafila—Shaubak—Dana—Wadi Musa—Petra—Ma'an—'Amman (along the Hejaz Railway). 'Amman—Zarqa—Mafraq—Irbid—'Ajlun—Qal'at er Rabad—Kufrinja—Jarash—Irbid—Ma'ad—south along the eastern part of the Jordan Valley to esh Shune and Allenby Bridge.

PHYSIOGRAPHIC CONDITIONS

Orography

Transjordan comprises three orographically distinct parts: (1) mountains, (2) steppe and desert plateau, (3) eastern part of the Jordan Rift Valley (Jordan Valley, Dead Sea, Wadi 'Araba).

The ascent from the Jordan Valley (100—300 m below sea level) to the mountains of Transjordan (reaching 1250 m in Gil'ad and 1650 m in Edom) is very steep, and thus most of the rivers in Transjordan run within narrow and deep ravines. Since the steep mountain slopes are exposed to the western rainbearing winds, they are covered by a much denser and less arid vegetation than the very arid slopes facing the Jordan Valley on the Cisjordanian side.

The narrow mountainous strip of Transjordan which stretches in the north—south direction is divided into four districts: Gil'ad (between the rivers Yarmuk and Yaboq), 'Ammon (between Yaboq and Arnon), Moav (between Arnon and Nahal Zered) and Se'ir or Edom (south of Nahal Zered).

East of the mountains lies a plateau which slopes gently towards the east and finally merges with the Syrian Desert. Vast stretches of this plateau are covered by Hammada.

*Geology**

As elsewhere in arid and semi-arid regions, geological conditions determine the character of the soils to such an extent that the geological map can be used largely for delimitation of soil areas. This review is based on the geological map and other publications by Blake (1939a, 1939b) and a map by Shaw (1947).

The most prominent geological formations are the following:

(1) The Archaic igneous rocks are limited mainly to mountain ranges reaching 1500 m and more above sea level, bordering on Wadi 'Araba as far as 'Aqaba and

* Our thanks are due to Prof. M. Avnimelech, who kindly read this chapter in manuscript.

further south. The rocks are granites, porphyry, dolorites, etc. The sand produced on their decomposition accumulates in dunes or sandy plains stretching over extensive areas of southern Edom.

(2) Nubian sandstone (of Palaeozoic and Mesozoic but chiefly of Lower Cretaceous age) is the main source of soil material in the southern part of Edom and along the eastern shores of the Dead Sea, in the Yaboq district and in a few other places. The vast deserts of Edom covered by Nubian sand are mostly flat plains upon which Zeugeberge of varying sizes appear scattered as if built artificially.

(3) Middle and Upper Cretaceous limestones become prominent from Edom northwards. The Cenomanian and Turonian rocks predominating in Cisjordan are found in Transjordan in N. Edom (Tafila district) and in Moav, but mainly in Gil'ad and Western 'Ammon. Hard limestones and dolomites of Cenomanian, Turonian and Lower Senonian ages are the main source of terra-rossa soils.

(4) The softer chalks of Middle and Upper Senonian age (Campanian—Maestrichtian) weather into greyish chalky soil very common in steppes and deserts. Lower Senonian is rather common in Moav (N. of Karak) and in N. Gil'ad (the Ramtha—Irbid district). Soft chalk containing layers of flint is most common.

(5) The Tertiary system is represented chiefly by Eocene formations. The Eocene rocks appear mainly to the east of the Hejaz Railway towards the eastern boundary of Transjordan, but also in the lower parts of the western slopes of Gil'ad.

(6) Basalt rocks are mainly confined to the northern boundary of Transjordan, in the Yarmuk area. A number of volcanic hills are also found in the south, near Zarqa Ma'in, between Dhiban and the Arnon river, near Aneze, Hasa, etc. Areas of lava are rather scarce. According to Blake the majority of volcanic eruptions occurred in Transjordan during Pliocene.

(7) The Diluvial deposits of the Jordan Valley comprise mainly gypsous chalky marls, known as Lissan Marls, which contain a fairly high percentage of soluble salts. In many places the Lissan marls are covered by alluvial soils washed down from the hill slopes.

(8) From the Pliocene onward heavy alluvial soils accumulated in larger valleys. Similarly, aeolian loess soil and sands were deposited upon steppes and deserts.

Soils

The main soil types of Transjordan are: (1) calcareous, (2) basalt, (3) sandy, (4) alluvial and (5) saline soils. Each type is represented by several variants.

(1) *Calcareous soils.* (a) Terra-rossa is produced on weathering under Mediterranean conditions of hard limestones and dolomites of the Cenomanian, Turonian and Lower Senonian formations (#1 of the Soil Map). The water-holding capacity and

permeability of terra-rossa are moderate, the $CaCO_3$ content is 5—15%, and, though generally devoid of a humus layer, this soil is rather fertile. The *Quercus calliprinos—Pistacia palaestina* Maquis and *Poterietum spinosi* are found on this soil.

Apart from terra-rossa formed in situ, one finds in 'Ammon, Moav and N. Edom considerable areas of plains and valleys covered by transported terra-rossa (#2 of the Soil Map). The hills in these districts are built of Senonian rocks which decompose into a grey chalky soil. Despite the rather low annual precipitation of these districts (250—400 mm), the areas of terra-rossa are successfully cultivated.

On the plains of NE Gil'ad, south of Irbid, terra rossa (#3 of the Soil Map) contains an admixture of basalt soil, similar to the fertile soils of the Yizre'el Plain. The composition of a soil sample of this type is recorded by Blake from 1 km south of Ramtha, 25 cm depth, and is given in Table I.

TABLE I

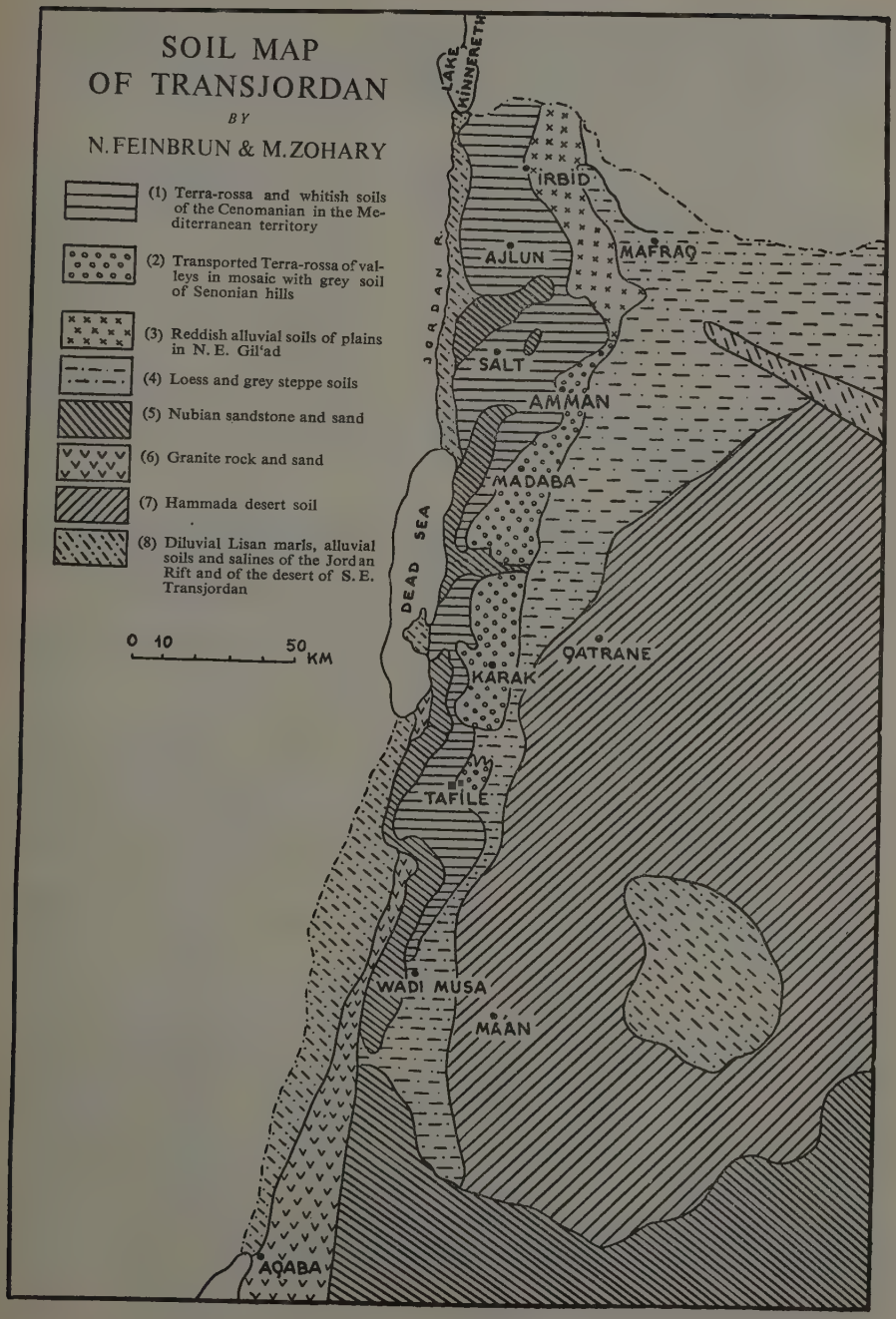
Mechanical analysis (%)		*Chemical analysis* (%) (*HCl extract*)	
H_2O	5.7	CO_2	3.00
Coarse sand	4.1	K_2O	1.58
Fine sand	38.5	P_2O	0.26
Clay and silt	52.8	N (Kjeldahl)	0.13

(b) White greyish soils of the Cenomanian (comprised in # 1 of the Soil Map). In the forest region of the hills of Gil'ad marls and soft chalk produce a whitish soil which appears in patches within areas of typical terra-rossa. Like similar soils on Mt. Carmel, they contain a high percentage of $CaCO_3$ and are poor in iron sesquioxides. Agriculturally these soils are mostly used for vineyards, whereas on terra-rossa winter crops and olive groves are grown. *Pinetum halepense* is found on this type of soil.

(c) Soils forming on Eocene chalks and limestones. Blake (1939) found a black soil almost devoid of $CaCO_3$ and rich in humus on the western slopes of Gil'ad facing the Jordan Valley. *Quercetum ithaburense* is found in the Taibe region (as also in Lower Galilee) on black soil overlying the white Eocene rock.

(d) Grey steppe soils and loess (#4 of the Soil Map). East of the rather narrow terra-rossa strip of Gil'ad, 'Ammon, Moav and N. Edom, vast areas are covered by soils produced by the weathering of Senonian chalk under arid conditions. On the hills these soils are skeletal, stony and grey in colour.

On flat plains there is a kind of dusty and yellowish-grey loess soil. Loess is quite widespread in Transjordan, though apart from Blake (1939b) nobody mentioned its occurrence there. It either overlies or intermingles with the grey soil produced by the chalky rock.


SOIL MAP
OF TRANSJORDAN
BY
N. FEINBRUN & M. ZOHARY
(1) Terra-rossa and whitish soils of the Cenomanian in the Mediterranean territory
(2) Transported Terra-rossa of valleys in mosaic with grey soil of Senonian hills
(3) Reddish alluvial soils of plains in N. E. Gil'ad
(4) Loess and grey steppe soils
(5) Nubian sandstone and sand
(6) Granite rock and sand
(7) Hammada desert soil
(8) Diluvial Lisan marls, alluvial soils and salines of the Jordan Rift and of the desert of S. E. Transjordan
0 10 50 KM
LAKE KINNERETH
JORDAN R.
DEAD SEA
IRBID
AJLUN
MAFRAQ
SALT
AMMAN
MADABA
QATRANE
KARAK
TAFILE
WADI MUSA
MAAN
AQABA

The fertility of loess is very high compared with other steppe soils. The high percentage of fine particles raises its water capacity; its permeability is comparatively low and its $CaCO_3$ content medium. The following data (Table II) are recorded by Blake from a loess sample taken on the Mafraq plain (0—25 cm depth):

TABLE II

Mechanical analysis (%)		*Chemical analysis* (%)	
H_2O	5.7	CO_2	2.03
Coarse sand	4.7	K_2O	1.40
Fine sand	31.8	P_2O	0.12
Clay and silt	61.0	N (Kjeldahl)	0.10

(e) White soils of Lissan marls in the Jordan Valley (part of # 8 of the Soil Map). These Diluvial soils contain $CaCO_3$, gypsum and soluble salts. In the Jordan Valley they are in many places covered by alluvium, and in the exposed parts some of the salts have been washed away.

(f) The Hammadas (#7 of the Soil Map). East and south of the loess area the landscape is dominated by vast Hammada deserts. They join the Hammadas of the Syrian Desert in the east and the sands desert of southern Edom in the south. Broad and shallow dry wadis interrupt the undulated plain covered by the Hammadas.

The soil of Hammada deserts is dusty, grey or white, and intermingled with gravel varying in colour and degree of coarseness. On the surface the gravel is exposed, the fine soil around it having been removed by wind erosion.

This soil is extremely sterile. In the southern part of the area perennials are limited to depressions and wadis only. Towards the north, perennial vegetation appears also on the plain itself, but even there the plant coverage of Hammada does not exceed 10—20%. The sterility of the soil is, however, not a result of its chemical or mechanical properties, but mainly of low precipitation, which is 150 mm in some places, and mostly not over 50 mm per annum.

Examination of a soil sample from the Hammada south of 'Amman gave the following figures*:

TABLE III

	Mechanical analysis (%)				*Chemical analysis* (%)		
Depth (*cm*)	0—10	10—20	20—30		0—10	10—20	20—30
Silt	15—0	15—0	10—0	Soluble salts	0.125	0.122	0.125
Clay	47.5	30.0	38.0	Cl	0.002	0.006	0.006
Fine sand	35.6	53.1	50.0	CO_2	13.6	13.7	14.2
Coarse sand	1.9	1.9	1.2	$CaCO_3$	29.6	29.7	30.93
*p*H	7.7	8.3	8.5	HCO_3	0.041	0.040	0.02

* Where no other source is given, the analyses were carried out in our Dept. of Botany.

(2) *Basalt soils.* These play a minor part in Transjordan. They are extensive in area only between Irbid and the Yarmuk river.

(3) *Sandy soils.* These differ according to the parent rock, which is either granite or Nubian sandstone.

(a) The granite sand forms small dunes or sandy plains in the area of granite rocks (# 6 of the Soil Map). The following figures were obtained from a sample taken in Wadi Ithm:

TABLE IV

	Mechanical analysis (%)				*Chemical analysis* (%)		
Depth (*cm*)	0—10	20—30	40		0—10	20—30	40
Silt	11.1	8.7	7.5	Soluble salts	0.167	0.100	1.02
Clay	traces	6.3	7.5	Cl	0.004	0.005	0.004
Fine sand	63.3	60.3	65.5	CO_2	10.6	5.3	5.4
Coarse sand	25.6	24.7	20.0	$CaCO_3$	23.1	11.6	11.8
*p*H	8.4	8.6	8.5	HCO_3	0.055	0.030	0.026

(b) The Nubian sand (# 5 of the Soil Map) is coarser and contains much less clay and silt. The figures below are from a sample taken 40 km S. of Ma'an:

TABLE V

	Mechanical analysis (%)				*Chemical analysis* %		
Depth (*cm*)	0—10	10—20	20—30		0—10	10—20	20—30
Silt	1.2	3.7	3.8	Soluble salts	0.050	0.040	0.042
Clay	traces	2.5	2.5	Cl	0.003	0.002	0.002
Fine sand	11.4	26.1	16.7	CO_2	0.14	0.33	0.37
Coarse sand	87.4	67.7	77.0	$CaCO_3$	0.31	0.71	0.81
*p*H	7.5	8.2	7.7	HCO_3	0.021	0.013	0.024

The vegetation on the Nubian sand changes with climatic conditions.

(4) *Alluvial soils.* (a) Soils of banks and river beds. Though differing in different places, all these soils have high humidity even in summer and a high humus content.

(b) Soils of oases of the Ghor (Jordan Valley). These soils are transported mostly by water courses from the hills and deposited upon Lissan marls. The depth and

composition of these soils which are heavy on the whole, vary especially with the distance from the hills. According to Blake, the percentage of salt is lowest at the foot of the hills and highest near the bed of the Jordan (Zor). Blake records: Cl under 0.1% and $CaCO_3$ about 50%.

The plant association typical of these soils is a type of *Scolymeto-Prosopidetum farcatae* in which trees such as *Zizyphus spina-christi* and *Balanites aegyptiaca* are prominent. The soils are cultivated to a great extent.

(5) *Saline soils*. Alternating with alluvial soils of the oases, saline soils occupy large areas of the Ghor, the Dead Sea shores and Wadi 'Araba. Salines are also found on the desert plateau. In the Jordan Valley they are mainly confined to the so-called Broken Lands. The percentage of soluble salts reaches here 4—5%. In parts of the Ghor where the soil is drier, the salt percentage is lower. In some parts of Wadi 'Araba as much as 18% of soluble salts were found.

On the desert plateau salines are formed in depressions where water collects in winter and evaporates in summer. Such are the salines of Jafr and of Azraq. In the absence of exact data from these salines, we shall cite figures obtained from a sample taken in a smaller saline depression within the Hammada area.

TABLE VI

	Mechanical analysis (%)				*Chemical analysis* (%)		
Depth (*cm*)	10—20	20—30	30—40		10—20	20—30	30—40
Silt	traces	traces	traces	Soluble salt	2.710	2.540	2.830
Clay	48.7	43.8	52.5	Cl	1.350	1.205	1.565
Fine sand	41.6	45.9	39.9	CO_2	16.3	16.4	15.8
Coarse sand	9.4	10.3	6.7	$CaCO_3$	35.5	34.7	34.7
*p*H	7.4	7.3	7.4	HCO_3	0.017	0.012	0.011

Climate

As in Cisjordan, three main variants of climate which differ particularly in amounts of precipitation can be distinguished in Transjordan: (a) Mediterranean (750—350 mm average annual rainfall), (b) Irano-Turanian (350—150 mm), and (c) Saharo-Sindian (150—0 mm). In (b) and (c), annual fluctuations of rainfall are very large.

Factors other than precipitation naturally also contribute to the characterization of the three climatic regions, but in respect to vegetation they are secondary in importance, whereas the amounts of precipitation are decisive. Therefore data on precipitation are a good basis for the subdivision of the country into three climatic districts, which also constitute vegetation and agricultural districts.

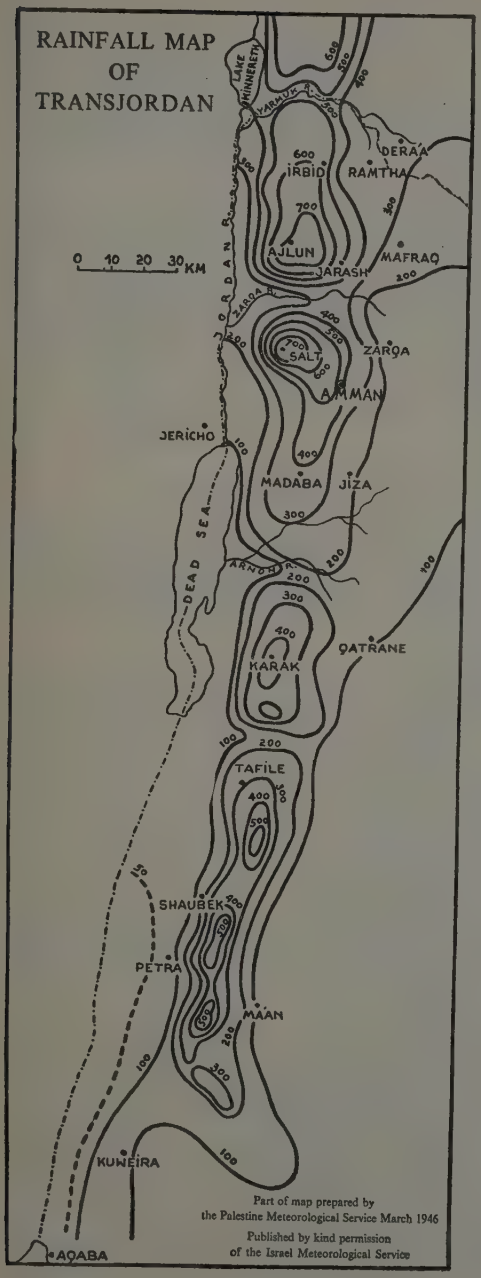


TABLE VII

Annual rainfall (mm) in Transjordan (average computed from data collected 1901—30)

N. Gil'ad	
Kafr Sum	522
Irbid	523
Um Qeis	493
Kharja	446
Hawara	945
Ramtha	310
Central Gil'ad	
Kufrinja	701
Kitta	680
Kafr Yuba	576
Taiyiba	502
Deir Abu Sa'id	511
Kafr Awan	495
'Ammon	
Salt	748
'Amman (R.A.F. Sta.)	307
Mafraq	202
Zarqa	149
Moav	
Madaba	385
Mazar	378
Hamud	310
Edom	
Shaubak, Nijl	381
Buseira	302
Tafila	275
Wadi Musa, Petra	200
Ma'an	48

Data on rainfall in Transjordan kindly supplied to us by the Israel Meteorological Service* and the rainfall map give a clear enough picture of climatic variation and climatic territories of Transjordan. In Table VII the data are arranged according to districts, from north to south.

* Our thanks are due to the Director of the Israel Meteorological Service for the permission to publish these data.

The figures cited above (and the rainfall map) show that precipitation is largest in the higher parts of Gil'ad and 'Ammon. There is a decrease towards north and west with decreasing altitude. There is a much more abrupt decrease eastwards, especially in 'Ammon, such as between es Salt and 'Amman. The same can be also seen in Moav and Edom, but data from these parts are lacking. The decrease in the southerly direction, from Moav to Edom, is obscured by the higher elevation of the mountains of Edom.

The rainfall map shows that the areas enclosed within isohyetes of 350 mm and above are rather restricted. Compared with Cisjordan, the most striking facts are, on the one hand, the absence of annual averages above 750 mm, and, on the other, the occurrence of isohyetes of 400—500 mm much farther south in Edom as compared with the Negev. The occurrence of a particular type of *Quercetum calliprini* at such low latitude (30° N. Lat.) is striking.

Snow occurs annually on the summits of Moav and Edom.

PHYTOGEOGRAPHICAL SUBDIVISION OF TRANSJORDAN

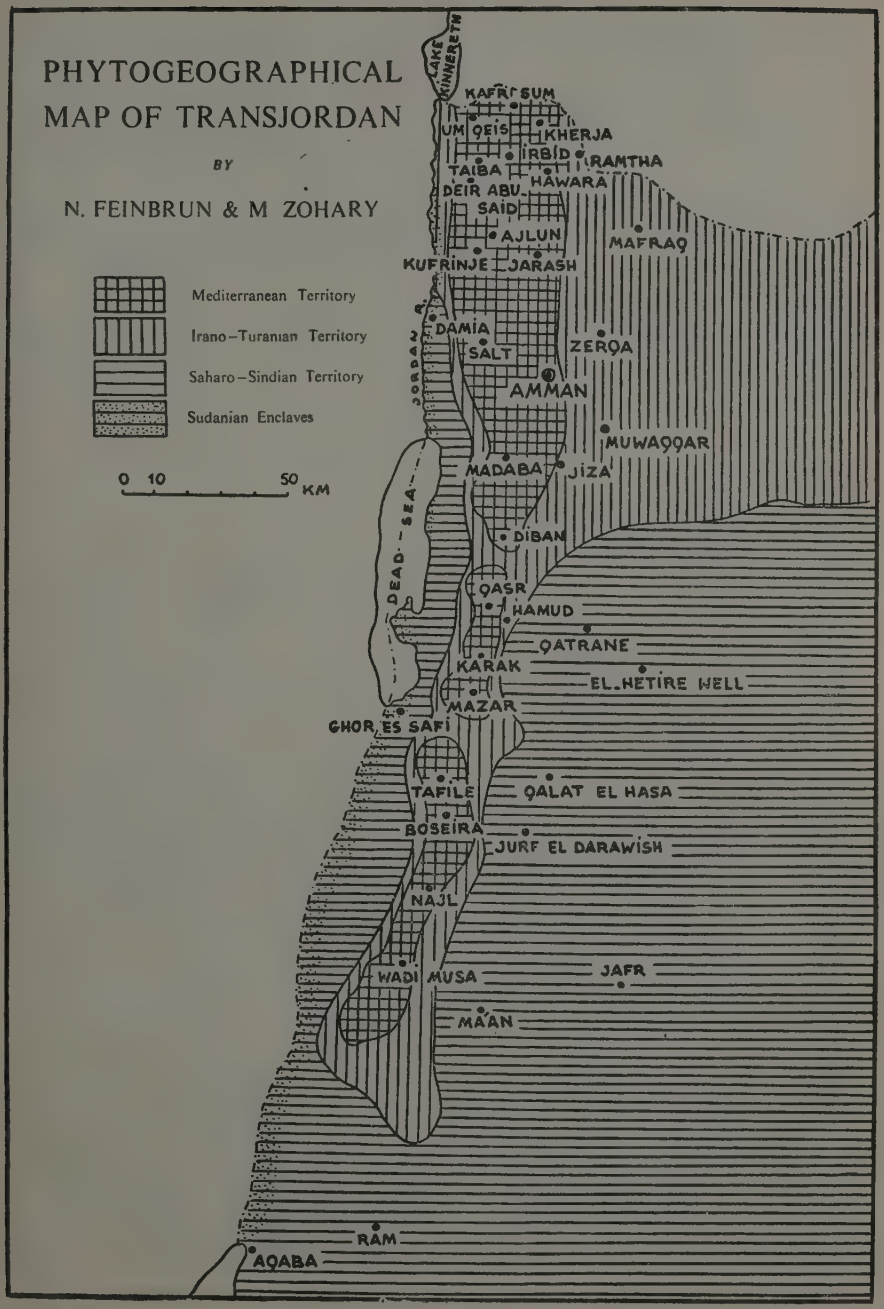
Transjordan, like Cisjordan, is situated at the meeting point of three phytogeographical regions: the Mediterranean, the Irano-Turanian and the Saharo-Sindian (Eig 1932). Transjordan can, therefore, be subdivided into three phytographical territories differing in climate, vegetation, agriculture, etc.

(1) The Mediterranean territory. Climatic conditions are similar to those of countries of the East Mediterranean, though the continental influences are more prominent here. Vegetation is characterized by a climax of Mediterranean Maquis and forest types. The agriculture is based mainly on non-irrigated winter and summer crops; fruit groves are typical. Terra-rossa is one of the most common soils in this area.

As seen on the map, the Mediterranean territory of Transjordan covers the hills of Gil'ad and the western parts of 'Ammon, Moav and N. Edom. The territory is narrow and interrupted in several places in the south, where it is limited to higher mountains.

(2) The Irano-Turanian territory is part of the Irano-Turanian region situated south and east of the Mediterranean region and comprising parts of Morocco, Algier, Tunis and Cyrenaica, Cis- and Transjordan, the Syrian Desert, Anatolia, N. Iraq, Iran, Turkestan and farther east to Mongolia.

In Transjordan the Irano-Turanian territory more or less surrounds the Mediterranean territory, except in the north. At the latitude of 'Amman, the otherwise narrow strip widens abruptly and connects in the east with the Irano-Turanian part of the Syrian Desert. With annual rainfall amounts of 150—350 mm, vegetation is typified by associations of dwarf-shrubs and herbs of comparatively high coverage. It does not comprise any forest or Maquis climax, although remnants of a *Pistacia atlantica* forest, found on the boundary of the adjoining Mediterranean territory, can be regarded as Irano-Turanian. The most wide-spread soils are loess and grey calcareous steppe soils.


PHYTOGEOGRAPHICAL MAP OF TRANSJORDAN
BY
N. FEINBRUN & M ZOHARY
Mediterranean Territory
Irano–Turanian Territory
Saharo–Sindian Territory
Sudanian Enclaves
0 10 50 KM
LAKE KINNERETH
KAFR SUM
UM QEIS
KHERJA
IRBID
RAMTHA
TAIBA
HAWARA
DEIR ABU SAID
AJLUN
MAFRAQ
KUFRINJE
JARASH
JORDAN R.
DAMIA
SALT
ZERQA
AMMAN
MUWAQQAR
MADABA
JIZA
DEAD SEA
DIBAN
QASR
HAMUD
QATRANE
KARAK
EL HETIRE WELL
MAZAR
GHOR ES SAFI
TAFILE
QALAT EL HASA
BOSEIRA
JURF EL DARAWISH
NAJL
WADI MUSA
JAFR
MAAN
RAM
AQABA

There is no stable agriculture, but a considerable area of the soils is ploughed for winter crops. Summer crops and non-irrigated fruit plantations are scarce.

(3) The Saharo-Sindian territory is part of the Saharo-Sindian region comprising the deserts of Sahara, from the Atlantic coast to the Red Sea, Sinai, Northern and Central Arabia, S. Iraq, S. Iran and the Sind province of the Indian Peninsula.

This territory is the largest of the three and occupies the southernmost and easternmost part of Transjordan. It is characterized by vast Hammada deserts in the east and by sand deserts in the south. The eastern parts of the Lower Jordan Valley, the Dead Sea and Wadi 'Araba also belong to the Saharo-Sindian territory.

Along the Jordan Valley and around the Dead Sea scattered oases represent enclaves of Sudanian vegetation.

VEGETATION OF THE MEDITERRANEAN TERRITORY

Maquis and forest associations

(1) *Pinetum halepense* (Figures 2 and 3)

Stands of natural pine forests as well as small forest remnants occur in two main centres, the northern — in Jebel 'Ajlun of Gil'ad, and the southern — in N. 'Ammon. The forests of the 'Ajlun area are well preserved, those of 'Ammon are in worse condition. From personal observation we can record pine forests near the town of 'Ajlun, 'Ain Jinna, 'Anjara, Kufrinja and Majdal. Various authors mentioned *Pinetum halepense* near Suf. Schumacher (1886) mentions "Nadelholzer" in the forest of Mt. Gil'ad and Aaronsohn saw pine forests between Kitta and Nahla, SW of Jarash. There are records in the literature of pine forests in various localities south of the Yaboq. Post and Dinsmore (1933) record *Pinus halepensis* from Jebel Hosha and from east of es Salt; Aaronsohn observed pines in Mahis (SE of Salt), from where the geologist Mr. B. Aisenstadt kindly brought us pine branches in 1944. Aaronsohn assumed that pines once occurred even further south, at Snobarat, 3 km S of Na'ur on the Madaba road (Snobarat — pines in Arabic). This is the southernmost point in Transjordan mentioned in connection with wild-growing *Pinus halepensis*.

Pinetum halepense in Transjordan is rather poor in composition, as seen from a sample record taken near the town of 'Ajlun.

Record: Flat ground, white chalky soil on Middle Cenomanian chalk; coverage 100%.

Pinus halepensis	3—1*	*Cistus villosus*	4—5
Arbutus andrachne	3—1	*Poterium spinosum*	3—3
Quercus calliprinos	1—1		

* First figure stands for combined coverage and density, second figure for sociability (Braun-Blanquet 1928).

The pine trees, 5—6 m high, grew 4 m apart. Numerous pine seedlings were found among the trees.

South of 'Ajlun, *Ononis natrix* was also found in *Pinetum halepense*. The predominance of *Arbutus* and *Cistus villosus* was conspicuous in all localities where pine forests were observed.

Pinetum halepense in Transjordan is found at 500—1000 m altitude. Edaphically it is confined to white or yellowish marly soil. This is especially proniment in 'Ajlun, where patches of this type of soil appear in the main area of terra-rossa, covered by the *Quercus calliprinos—Pistacia palaestina* Maquis.

A noteworthy finding were trees of *Cupressus sempervirens* var. *horizontalis* in the 'Ajlun *Pinetum* area, between the villages of Kufrinja and 'Anjara. They grew on white chalky and stony ground, accompanied by *Arbutus andrachne* and *Cistus villosus*. One group contained five small trees, two other trees stood somewhat further apart; all were only 1 m high and apparently damaged by sheep. The villagers of 'Anjara told us about some twenty more wild cypresses which they called 'Bihil'.

Another stand of *Cupressus* preserved in Edom, near Sail Dana, has been described by Chapman (1947). Though in quite different edaphic conditions (on Nubian sandstone) and under more arid climate, the *Cupressus* stand in Edom bears the same isolated, possibly relic character. Curiously enough *Cupressus sempervirens* has never been found growing wild in Cisjordan and its nearest stand is in the Lebanon.

(2) *Quercetum calliprini*

Quercetum calliprini is represented by two main types: (a) *Q. calliprinos—Pistacia palaestina* association in Gil'ad and 'Ammon, and (b) *Q. calliprinos—Juniperus phoenicea* association in Edom.

(a) *Quercus calliprinos—Pistacia palaestina* association (Eig 1946). This type of Maquis, common in Cisjordan, covers a great part of mountain slopes in Gil'ad at 500—1200 m altitude, from Hush in the north to the Yaboq river in the south. In the 'Ajlun and Kafkafa mountains it is fairly well preserved (Figure 1 and 4). South of the Yaboq Maquis is more sporadic and appears in smaller areas on hills and mountain tops, at 500—1200 m, especially in the es Salt area and on Jebel Hosha, and further east near Mahis and es Suweilih. Further south the Maquis patches become smaller and smaller, appearing on isolated mountains, such as W of Na'ur (Az-Zubbad), etc. We have not a single record on the occurrence and composition of Maquis in Moav, where a special study should be made. It seems, however, that at present there is no Maquis left south of Az-Zubbad and as far as Wadi Zered.

The western boundary of the Maquis area of this *Quercetum calliprini* type runs along the 500 m contour line. From that altitude down this Maquis type changes places with the *Quercetum ithaburense* open forest (Figure 6). East of the *Quercetum calliprini* area some remnants of a *Pistacia atlantica* forest are found. Within the Maquis area large stretches are occupied by East Mediterranean Batha associations, but individual shrubby components of *Quercetum calliprini* are often found scattered within the Batha.

As mentioned above, this type of Maquis is confined to terra-rossa formed on hard limestones and dolomites of the Cenomanian and Lower Senonian.

Though our records on the floristic composition of *Quercetum calliprini* in Transjordan are incomplete, this type of Maquis can be identified with the type known to us from Galilee, and can be designated as *Quercetum calliprini infectorietosum*. However, there are fewer components in this association in Transjordan than in Galilee.

The list of components of two *Quercetum calliprini* stands from Gil'ad: (1) near Dhar Santa, NE of 'Ajlun, 1100 m altitude, (2) near Kufrinja, 800 m altitude, is given below.

	Stand (1)	*Stand* (2)		*Stand* (1)	*Stand* (2)
Quercus calliprinos	+	+	*Lonicera etrusca*	+	—
Q. infectoria	+	+	*Rubia olivieri*	+	—
Pistacia palaestina	+	+	*Asparagus aphyllus*	+	—
Ceratonia siliqua	—	+	*Phlomis viscosa*	—	+
Styrax officinalis	—	+	*Cistus villosus*	—	+
Pyrus syriaca	—	+	*Ononis natrix*	—	+

It is remarkable that several trees and shrubs which are common in the Maquis of Cisjordan were never found by us in Transjordan. The species prominent by their absence and so far not reported from Transjordan are:

Laurus nobilis
Cercis siliquastrum
Phillyrea media
Pistacia lentiscus
Spartium junceum
Salvia triloba
Satureja thymbra.

Poterium spinosum is not as common here as in Cisjordan. *Ononis natrix* is, on the contrary, very common on the Senonian formation, even in the Maquis region.

(b) *Quercus calliprinos—Juniperus phoenicea* association (Figures 7—9). This association is confined to the higher parts of the Edom mountains, from a few kilometres S. of Tafila to the environs of Petra. In the far south it is impoverished by the loss of *Quercus calliprinos*, and can be designated as *Juniperetum phoeniceae*. The whole area of this Maquis lies between 30°50′ and 30°20′ N. Lat. At these latitudes, approaching the latitude of Cairo, Mediterranean Maquis can exist naturally only in higher altitudes. In fact, the mountains bearing this type of *Quercetum* in Edom reach the height of 1000—1500 m, and at some points even 1650 m. At these high altitudes Maquis is found on the western slopes, as well as on eastern and northern slopes, for example, north of Shaubak and between Shaubak and Petra. In the north of the area, it grows on the Cenomanian limestone and on terra-rossa, but in the south it is confined to the Nubian sandstone.

The following are the main components of the *Quercus calliprinos—Juniperus phoenicea* association:

Quercus calliprinos
Juniperus phoenicea
Pistacia palaestina
Crataegus azarolus
Rhamnus palaestina
Daphne linearifolia
(endemic in Edom)

More exact ecological data on this extremely interesting Maquis type are still lacking. Even data on rainfall are very scarce. The figures of 275 mm for Tafila, 381 mm for Shaubak and 200 mm for Wadi Musa appear to be rather low.

The Maquis of Edom is one of the most arid variants of *Quercetum calliprini*, which reaches here the southernmost point of its distribution.

The occurrence of *Juniperus phoenicea* in Edom is most remarkable. *Juniperus phoenicea* is an Omni-Mediterranean species, but it occurs neither in the Lebanon and Syria, nor in Cisjordan. On the other hand, it is found on Hallal and Jelleg mountains of the Sinai Peninsula.

The edaphic requirements of *Juniperus phoenicea* are emphasized by its preference for sandy soils. In Edom it is mostly confined to the Nubian sandstone, in Cyprus it occurs on sandstone in the northern Kyrenia range, but also on conglomerate. Emberger (1939) describes it from Morocco, where it grows on maritime sands as well as on the southern slopes of the Atlas. Edaphic data from its habitat in the Sinai Peninsula are lacking.

In Edom south of Petra we observed *Artemisia herba-alba* together with *Ononis natrix* in the lower stratum of an open *Juniperetum phoenicea*. Emberger (1939) records from Morocco *Artemisia herba-alba* as a component of the underwood of *Juniperetum*. He also found *Artemisietum herbae-albae* and other Irano-Turanian steppe associations bordering the *Juniperetum* in the south. The endemic *Daphne linearifolia* is a shrub found in the *Juniperetum* of Edom.

Near Petra a very scant *Juniperetum phoenicea* is found on the upper parts of the slopes, whereas the lower parts are occupied by *Retametum roetami*.

(3) *Quercetum ithaburense* (Eig 1933)

The area of *Quercetum ithaburense* forms a narrow strip in W. Gil'ad and is confined to Eocene rocks. We crossed it between Irbid and Ma'ad (Figure 6), and then travelled along it in the Jordan Valley south of Ma'ad. It is bordered by *Quercetum calliprini* higher up in the hills towards east and by *Zizyphetum loti* lower down in the west. These changes in vegetation are connected not only with changes in altitude and thus with climate, but also with geological formation and consequently edaphic conditions.

Quercetum ithaburense is confined to altitudes below 500 m as it is in Cisjordan. Eig (1933) cited literature records of this forest in Transjordan. Schumacher (1920) in his map gives data on its occurrence in Gil'ad. In Moab and Edom *Quercetum ithaburense* does not occur at all.

The main components of *Quercetum ithaburense* are *Quercus ithaburensis*, *Q. calliprinos* and *Styrax officinalis*.

Mediterranean Batha associations

The main Batha associations in Transjordan are *Cistetum villosi*, *Poterietum spinosi* and the *Salvia dominica—Ballota undulata* association. The latter is the largest in extent and occurs in several variants.

(1) *Cistetum villosi*. This association occurs in patches in the clearings of *Pinetum halepense* and of *Quercetum calliprini*. On our vegetation map it is included in the area of these forests and Maquis.

In Cisjordan *Cistus villosus* is as a rule associated with *Cistus salviifolius*, to such an extent that we could not find what are the differences in their ecological requirements. It therefore seems significant that in Transjordan *C. salviifolius* is rather rare. Here it may be mentioned that neither *Salvietum trilobae*, an association common in the vicinity of the *Quercus calliprinos* Maquis, nor *Saturejetum thymbrae*, common in the area of *Pinetum halepense*, have so far been recorded from Transjordan.

(2) *Poterietum spinosi mediterraneum* (Eig 1938).

One of the most striking features of the Mediterranean vegetation of Transjordan is the restricted occurrence of *Poterietum spinosi*, even in proportion to the size of its Mediterranean territory. The explanation of the fact is no doubt in the restricted occurrence of the Cenomanian—Turanian formation and of terra-rossa, especially in 'Ammon and Moav. In Gil'ad, where forests and Maquis are found on Senonian chalk and limestone, the open areas, apparently once cultivated and later abandoned, are occupied by the *Salvia—Ballota* association. *Poterietum spinosi* makes its appearance on terra-rossa only, in the areas of the Cenomanian formation. Similarly no *Poterietum* is found in Moav on the Senonian formation prevailing between Madaba and Tafila. *Poterietum* is found again only south of Tafila, where it is also confined to the Cenomanian formation. Further south, however, it reaches its climatic limit.

In our records *Poterietum spinosi* is noted at altitudes between 600 and 1150 m.

(3) *Salvia dominica—Ballota undulata* association (=*Salvia graveolens—Ballota undulata* assoc. by Eig 1946) and its variants (Figures 11 and 12).

This association is the commonest of the Mediterranean associations. It occurs in northern Gil'ad, eastern 'Ammon, Moav and northern Edom. In Gil'ad it is found on forest clearings and advances into abandoned cultivated soil. In eastern 'Ammon and in Moav it seems to constitute the climax on Eocene and Senonian. On the alluvial soil of plains and broader valleys, however, a forest or Maquis climax is probable, as evidenced by the occurrence of shrubs and even trees of *Crataegus azarolus* in the midst of cultivated fields.

For the genesis of the *Salvia—Ballota* association it is essential that both main components, as well as some of the less common ones, be avoided by sheep and goats.

Almost everywhere this association is found on white or grey stony soils formed on Senonian rocks; in valleys between the hills the soil is sometimes red or even brown. In Cisjordan this association is also found on soft Upper Senonian and on Eocene rocks (Eig 1946, Zohary and Feinbrun 1951). Since this association often occurs on the boundary of the Irano-Turanian *Artemisietum herbae-albae*, it is justifiable to assume that this is one of the most xeric types of the Mediterranean Batha.

Two variants of this association were designated:

(a) Type variant, dominant chiefly in Gil'ad and 'Ammon. It is rich in species but constant in composition. The following species are characteristic:

Salvia dominica
Ballota undulata
Ononis natrix
Noëa mucronata
Verbascum eremobium
Anchusa strigosa
Echinops blancheana
Onopordon palaestinum
Carlina corymbosa
Scrophularia xanthoglossa
Eryngium glomeratum
Convolvulus dorycnium
Poa ?sinaica
Dianthus multipunctatus
Varthemia iphionoides

(b) The second variant which occurs chiefly in Moav, between the Arnon river (W. Mujib) and Wadi Hasa, we designate as *Ballota undulata—Ononis natrix* sub-association. It is characterized by the absence of *Salvia dominica* and is found under less favourable climatic conditions (lower precipitation).

On the high plateau of northern Moav reaching 1000 m and more, the *Salvia—Ballota* association is replaced by the *Astragalus bethlehemiticus—Marrabium libanoticum* association. This association, which we found north of Karak, is noted by the presence of subalpine species, some of which are tragacanthic. Neither *Salvia dominica* nor *Ballota undulata* were found there. The following species were recorded on the plateau between Karak and Rabat Moav on fallow soil found among cultivated fields:

Ononis natrix
Marrubium libanoticum
Astragalus bethlehemiticus
Noëa mucronata
Cousinia moabitica
Verbascum eremobium
Pterocephalus sp.
Poa sinaica
Dactylis glomerata
Phlomis brachyodon var. *antilibanotica*

Field crops and non-irrigated, usually deciduous, fruit trees are found everywhere in the area of the *Salvia dominica—Ballota undulata* association.

Segetal plant communities of the Mediterranean territory

Three principal plant associations of non-irrigated habitats will be discussed. All three are mostly found on terra-rossa or reddish alluvial soils, but each is characteristic for a different geographical district.

(1) The *Carthamus tenuis—Ononis leiosperma* association (Eig 1946, p. 236), common in Cisjordan, is also common in Gil'ad and northern 'Ammon on land cultivated for winter crops.

(2) In the district between 'Amman and Madaba the common segetal association is that of *Ononis letosperma—Phlomis orientalis.*

(3) In Moav and those parts of Edom where the Batha consists of the *Salvia dominica—Ballota undulata* association, the segetal community is the *Ononis leiosperma—Phlomis pungens* association.

All three units may represent only variants of the same association, since their floristic composition is similar, but each of them differs by one of their dominant species. In all three one finds a winter aspect on land cultivated for winter crops, with numerous annual weeds, and a summer aspect, with a few typical summer annuals, such as *Chrozophora tinctoria*, *Molucella laevis*, *Euphorbia lanata* and a few others.

VEGETATION OF THE IRANO-TURANIAN TERRITORY

The western slopes facing Jordan Valley

(1) *Zizyphetum loti* (Figure 20). The dominant species, *Zizyphus lotus*, is a thorny deeply rooted shrub (about 2 m in diameter), intricately branched and spreading close to the ground. Its range of distribution is very wide, stretching from Morocco eastwards along N. Africa and along the Eastern Mediterranean as far as Antiochia. In Upper and Central Jordan Valley *Zizyphetum loti* spreads over the eastern and western slopes at altitudes ranging between—200 m and+300 m. One of its main characteristics is its thermophily. It is rather modest in its requirements of precipitation but it does not occur in places with annual rainfall below 200 mm. The soil under *Zizyphetum loti* is non-saline and well aerated.

(2) *Retama duriaei—Rhus tripartita* (=*Rh. oxyacanthoides*) association (Eig 1946, p. 208). This association is found along the lower mountain slopes facing the Jordan Valley betwwen Wadi Nimrin (W. Shuaib) in the south and W. Yabbis in the north. It is confined to a very hard Cenomanian—Turonian limestone which also appears on the opposite side of the Jordan Valley. Eig (1946) records twelve shrubby species in this association, six of which, including *Retama* and *Rhus*, are typical chasmophytes rooting in rock crevices or even boring their way into the rock itself. The ecological requirements of *Retama duriaei* as compared with *Retama roetam* are discussed by Zohary (1945).

The vegetation on the plateau east of the Transjordan mountains

Pistacietum atlanticae (Steppe forest). This association was found as a degraded remnant of a forest represented by stunted trees in eastern Gil'ad only (east of Wadi Waran). Scattered trees are mentioned by G. Le Strange (in Schumacher 1886) NE of 'Ammon, and it seems that the area of *Pistacietum atlanticae* forms a strip along the eastern edge of the hilly region of Transjordan. Tristram (1873) described *Pistacia* from Jebel Atarus in Moav. We found well developed and even huge trees north of 'Ain Musa in Edom close to *Quercetum calliprini*. Additional data are given by Zohary (1940a).

Dwarf-shrub associations. Hundreds of square kilometres of the plateau adjacent to the Mediterranean territory are under steppe vegetation. Three main plant associations are of importance: *Artemisietum herbae-albae*, *Anabasis haussknechtii—Poa sinaica* association, *Haloxylon articulatum—Salsola villosa* association.

(1) *Artemisietum herbae-albae* is represented by several subassociations differing by their edaphic and to a certain degree climatic requirements.

(a) *Artemisietum herbae-albae Ononidetosum* (Eig 1946, p. 199). This subassociation is found on hill slopes in areas closest to the Mediterranean territories both in Cis- and Transjordan. Sometimes it even penetrates as underwood into *Quercetum calliprini*. Thus we found *Artemisia herba-alba* and *Ononis natrix* in a *Quercetum calliprini* near Wadi Musa (above 1000 m) in Edom. *Ononis natrix* itself is a Mediterranean species. These facts emphasize the higher climatic requirements of this subassociation. Edaphically it is characterized by a Senonian white chalky soil.

(b) *Artemisietum herbae-albae Stipetosum hohenackeri*. This variant is commonest on low hills or flat plains in Moav and especially in Edom (Figures 13 and 14). The soil is loess or a grey steppe soil.

The following table shows the main components of this subassociation recorded in July 1942 in three localities: Record (1): 20 km east of Dhiban, Moav; Record (2): about halfway between Wadi Gharandal and 'Ain Musa, NE of 'Ain Musa, Edom; Record (3): 20 km east of 'Ain Musa. All three records were taken in large stands of very homogeneous appearance.

	Rec. (1)	*Rec.* (2)	*Rec.* (3)
Artemisia herba-alba	4—3	3—4	3—3
Noëa mucronata	—	1—1	+—1
Haloxylon articulatum	+	—	—
Anabasis articulata	+	—	+
Poa sinaica	4—1	2—2	—
Stipa hohenackeri	—	2—1	+
Teucrium polium	+	—	—
Dianthus multipunctatus	+	—	—
Eremopyrum orientale	—	+	+
Senecio coronopifolius	—	—	+

In Edom this subassociation borders in the east on *Anabasidetum articulati*.

(c) *Artemisietum herbae-albae Haloxylonetosum articulati* (Zohary and Feinbrun 1951). This subassociation is a transition form to the *Haloxylon articulatum — Salsola villosa* association. In northern Transjordan it occurs mostly in the eastern parts of the area occupied by *Artemisietum herbae-albae*. It is found on the deeper soils of the plains.

Artemisietum herbae-albae can be used as an adequate indicator of marginal conditions for agriculture. Its boundaries towards the desert roughly correspond to the limit of non-irrigated crops, especially of barley. The area is, however, subjected to considerable variation in annual precipitation and the resulting recurrent years of drought. The agriculture can thus be designated as sporadic.

The soils under *Artemisietum herbae-albae* are non-saline, of a medium water capacity, and are suitable for irrigation where topography is favourable.

(2) *Anabasis haussknechtii—Poa sinaica* association (Eig 1946, p. 202) is found on deep loess soil of plains and depressions in Moav close to *Artemisietum herbae-*

albae. A rather similar variant of this association, *Anabasis haussknechtii—Plantago coronopus* (Eig 1946), is known from the Negev.

(3) *Haloxylon articulatum—Salsola villosa* association (Eig 1946, p. 201). This association is found in the less favourable parts of the Irano-Turanian territory (150—200 mm rainfall), and even in depressions and wadis of the Hammada area, where annual precipitation is 150 mm or less; there, however, vegetation enjoys better water supply owing to topography. The soil is usually a compact grey steppe soil comprising fine gravel. The floristic composition of this association is characterized by a high percentage of annuals and geophytes. *Haloxylon articulatum* and *Salsola vermiculata* ssp. *villosa* are the main chamaephytes, the former peculiar by its deep roots which can withstand repeated ploughing. *Poa sinaica* forming small tufts can reach a rather high coverage. This association was found along the eastern edges of the Irano-Turanian territory (near Mafraq, east of Gil'ad, in Moav and in Edom).

Segetal vegetation of the Irano-Turanian territory

Contrary to Mediterranean segetal vegetation, it is represented by a winter aspect only. The typical association of crop fields cultivated in the area of *Artemisietum herbae-albae* is *Achilletum santolinae* (Eig 1946, p. 237). This association occurs on the loess soil of the plains, as it does in the Northern Negev (Zohary and Feinbrun 1951).

VEGETATION OF THE SAHARO-SINDIAN TERRITORY

The area of the Saharo-Sindian vegetation in Transjordan can be subdivided into four main districts, differing in their ecological conditions. Largest in area and most homogeneous in character is the eastern part of the Plateau, which can be designated as the Hammada district. The second district, stretching between Ma'an (Edom) and 'Aqaba, is characterized by sandy deserts. The sand is derived from granites and the Nubian sandstone and forms small dunes or sandy plains. The third district consists of the lower parts of the slopes facing the Jordan Valley. The fourth comprises the salines of the Jordan Valley and the Dead Sea, and of the eastern desert.

Vegetation of the Hammada district

Two main plant associations are common to this district which receives only 25—100 mm annual rain.

(1) *Anabasidetum articulati* occupies the greater part of the district. Though homogeneous in aspect, it probably comprises several variants. Its degree of coverage is very low (sometimes reduced to 1%) and its composition is poor. *Anabasis articulata* is a leafless shrub with very deep roots. Its main growing season is summer and its flowering begins at the end of summer. It grows on the Hammada plains, but, where precipitation is at its lowest, it is driven into depressions and wadis, leaving the flat plains devoid of vegetation (Figures 15 and 16). In the patches where *Anabasis* shrubs grow, the soil usually does not contain a high percentage of chlorides, though

Anabasis articulata can stand a certain degree of salinity. The association can be considered as non-halophytic.

In Wadi 'Araba the vegetation of the Hammada comprises, apart from *Anabasidetum articulatae*, a subassociation prominent by its arboreal components. This subassociation, namely *Anabasidetum articulatae Acacietosum* (Zohary 1945), is common in shallow wadis and depressions, in more favourable edaphic conditions than the surrounding Hammada. The main components of this subassociation are *Anabasis articulata*, *Lycium arabicum* and the Sudanian trees *Acacia raddiana* and *Acacia spirocarpa*. It seems probable that higher winter temperatures compared with those prevailing in E. Transjordan are connected with the occurrence of this subassociation in Wadi 'Araba.

(2) *Chenolea arabica—Salsola villosa* association (Eig 1946, p. 217) is confined to stony hills scattered within the area of the much more common *Anabasidetum articulati*.

Vegetation of sandy deserts

Contrary to the conventional ideas on sandy deserts, they are much more densely populated by plants than Hammadas. In spite of the very scant amount of rain (25—100 mm), the vegetation of the sandy deserts of Edom is relatively rich. This is due to rain absorption and to the protection of moisture by the upper layers of the sands. The soils are non-saline and their wilting point is rather low.

The two types of sandy soil, granite and Nubian sands, show distinct differences in vegetation.

The plant associations of the Nubian sand areas, the *Anabasis articulata—Zilla spinosa* association and its variant *Noëtosum mucronatae* (Eig 1946, p. 217), are floristically related to those of the Hammada, but their coverage is considerably higher (Figure 17). Both associations comprise numerous psammophytic annuals.

The vegetation of the granite sandy soils shows no floristic connections with that of the Hammada, but is similar to the vegetation of sandy deserts of Wadi 'Araba, Sinai, N. Arabia and the Eastern Egyptian Desert. The plant associations are: *Haloxyletum salicornici* (Figure 18) and *Haloxyletum persici* (Eig 1946). Their main area is in Wadi Ithm, between Quweira and 'Aqaba (Figure 19). *Haloxyletum persici* deserves special attention since its main component, *H. persicum*, is a small tree well known in the deserts of Transcaspia where it forms a kind of desert forest known as Saxaul forests. This association is also of importance in Nefud (Arabia), where its components are a valuable source of fuel and pasture for camels (Zohary 1940b).

Both mentioned associations are concentrated mostly in valleys and depressions.

Vegetation of the Nubian sandstone slopes facing the Dead Sea and Wadi 'Araba

The steep western slopes of 'Ammon, Moav and Edom facing the Dead Sea and the eastern edge of Wadi 'Araba consist mostly of barren Nubian sandstone. The scanty vegetation of these slopes was not studied by us. In some parts it is probably nearest *Gymnocarpetum fruticosi*.

The following dwarf-shrubs, most of them lithophytes, are quoted in the diaries of Aaronsohn: from Zarqa Ma'in to 'Ain ez Zera': *Gymnocarpus fruticosus, Fagonia grandiflora, Astragalus spinosus;* from Ratieh through et Tlah to Fenan, SE of the Dead Sea: *Podonosma syriaca, Noëa mucronata, Varthemia iphionoides, Globularia arabica.*

In spring the Nubian sandstone may be covered rather densely by therophytes like *Stipa tortilis* (Aaronsohn).

Vegetation of larger ravines

Three larger rivers of Transjordan, namely Zarqa, Arnon and Zered, cut wide and deep ravines across the mountains. The slopes of these valleys consist mainly of Nubian sandstone. *Retametum roetami* is found on these slopes, whereas the stony bed of the water course usually bears a strip of *Nerium oleander.*

Vegetation of salines

This vegetation comprises hydro-halophytic and xero-halophytic associations. The former are confined to salines with a high water content, the latter are found on rather dry soil.

(1) *Hydro-halophytic associations.*

(a) *Arthrocnemum glaucum—Tamarix deserti* (Zohary and Orshansky 1949, under *Arthr. glaucum—Tamarix tetragyna*) association is common in the tide region of the Dead Sea. *Arthrocnemum glaucum* forms a rather dense thicket in which *Tamarix* shrubs or trees are scattered. Other components are rather scarce. The soil has a high water content throughout the year, and comprises up to 10% soluble salts. The ecology of this association has been studied by Shmueli (1948).

(b) *Suaeda fruticosa—Suaeda monoica* association is similar to the preceding association in the high humidity and salinity of the soil. It is found near the Dead Sea and north of the Gulf of 'Aqaba, somewhat more inland than the *Arthrocnemum—Tamarix* association.

(c) *Suaedetum palaestinae* (Eig 1946, p. 222) is found in the Ghor Nimrin and probably in some parts of the Middle Jordan Valley.

(d) *Nitrarietum retusae* (Eig 1946) was observed by us in Wadi Sirkhan near Qasr el Azraq.

(2) *Xero-halophytic associations.*

(a) *Atriplicetum halimi* (Eig 1946). The upper soil layers contain considerable quantities of chlorides but the deep roots of *Atriplex halimus* absorb water from much deeper layers.

(b) *Salsoletum tetrandrae* (Eig 1946) is a typical xero-halophytic association. It is confined to a rather dry soil with a rather high degree of salinity (ca. 2%). This association is common in the Lower Jordan Valley, and is also found in a restricted area in the depression near Jurf ed Derawish.

Hydrophytic vegetation

The main centre of hydrophytic vegetation is in the Jordan Valley. Following the meanders of the river Jordan there is a narrow strip of *Populetum euphraticae. Tamaricetum jordanis* is found on its inland side. It is confined to soils which are only slightly saline. Further away from the water course, in wet saline soils, *Tamaricetum deserti* develops in patches. Where trees are cut away *Glycyrrhizetum glabrae* densely covers the soil in summer. In winter *Glycyrrhiza glabra* is dormant, mainly reduced to underground rhizomes usually reaching considerable depth. Further away from the course of the Jordan is *Prosopidetum farcatae* which is confined also to deep mostly cultivated alluvial soil.

Along the stony banks of permanent tributaries of the Jordan and of the Dead Sea, associations of the *Nerion oleandri* alliance, such as *Nerietum oleandri* and *Arundinetum donacis*, are very common.

SUDANIAN ENCLAVES

Along the Jordan Valley and Wadi 'Araba which are climatically part of the Saharo-Sindian territory one finds scattered a series of smaller and larger enclaves of arboreal Sudanian vegetation belonging to the *Acacietalia* (Eig 1938). These enclaves are oases which enjoy high temperatures combined with sufficient supply of non-saline water. They are, therefore, confined either to the vicinity of permanent springs or to larger outlet regions of water bodies.

Among the numerous enclaves found between 'Aqaba and the Middle Jordan Valley we shall mention the larger ones, such as Ghor el Feifa, Ghor es Safi, Ghor el Mazra', Callirrhoë, the delta of the Yaboq river, Ghor Kafrein, Ghor Nimrin, Wadi Kufrinja, Wadi Yabbis, etc.

The most common plant association of these enclaves is the *Zizyphus spina-christi—Balanites aegyptiaca* association (Figure 21) (Eig 1946, p. 223). Second in importance is *Acacietum tortilidis palaestinum* (Eig 1946, p. 222). Along the Dead Sea shores we observed the *Zizyphus spina-christi—Moringa aptera* association.

The Sudanian enclaves are often cultivated under irrigation.

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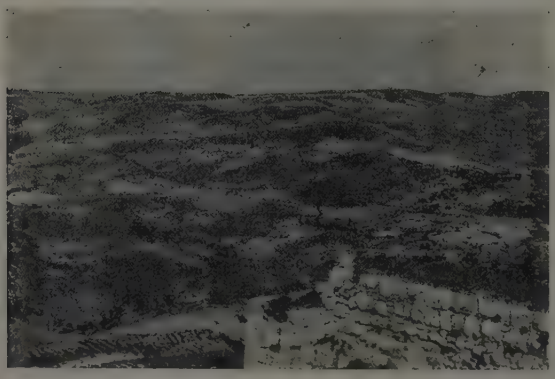


Figure 1
General view of *Quercus calliprinos—Pistacia palaestina* Maquis and *Pinetum halepense* forest taken from Qal'at er Rabad, Jebel 'Ajlun, Gil'ad.

Figure 2
Pinetum halepense in Jebel 'Ajlun near the town of 'Ajlun (Gil'ad).

Figure 3
Pinetum halepense near Majdal (Gil'ad).

Figure 4
Quercus calliprinos—Pistacia palaestina Maquis near Ma'arat Mooftah.

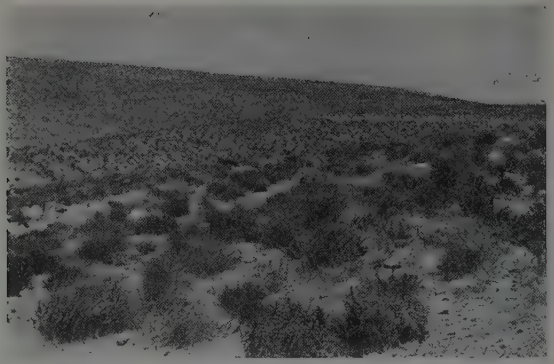
Figure 5
Huge *Quercus calliprinos* tree in Wadi Waran (E. Gil'ad). Scanty *Quercus* shrubs on hill slope.

Figure 6
Quercetum ithaburense near Kafr Kam in Gil'ad (between Irbid and Ma'ad).

Figure 7
Quercus calliprinos—Juniperus phoenicea Maquis north of Dana (Edom).

← Figure 8
Quercus calliprinos—Juniperus phoenicea Maquis north of Dana (Edom).
Figure 9
↓

Figure 10
Daphne linearifolia shrubs in a *Quercus calliprinos — Juniperus phoenicea* Maquis remnant near Rashadiya, 20 km S.of Tafila (Edom).



← Figure 11
Salvia dominica—Ballota undulata association on stony hills, N. of Wadi Wala (S. 'Ammon). *Retama roetam* shrubs along the bed of wadi.

Figure 12
↓

Figure 13
Artemisietum herbae-albae 20 km S. of Ma'an (Edom).

Figure 14
Artemisietum h. a. in depression of a Hammada plain, 20 km S. cf Jurf ed Darawish.

Figure 15 →
Stony Hammada desert devoid of vegetation, N. of Ma'an.
Figure 16
↓

Figure 17
El-Hisma Plain (Edom), Nubian sandstone and sandy plain. *Anabasis articulata — Zilla spinosa Noëëtosum mucronatae.*

Figure 18
Wadi Madeifan (Edom). Granite mountains and sand. *Haloxylonetum salicornici.*

Figure 19
Wadi Madeifan (Edom), 12 km S. of Quweira. Granite mountains. *Haloxylonetum persici* on sandy soil.

Figure 20
Zizyphetum loti on hills near Wadi Yabbis.

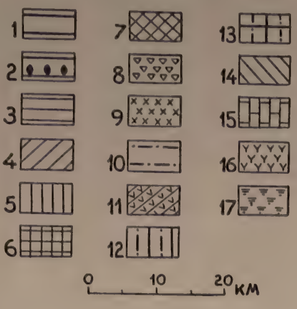
Figure 21
Middle Jordan Valley near Wadi Yabbis. El Ghor. *Zizyphetum spinae-christi* oasis.

Figure 22
Group of wild *Acacia albida* trees S. of Wadi el Taibe (Upper Jordan Valley).

VEGETATION MAP OF TRANSJORDAN

BY

N. FEINBRUN & M. ZOHARY



LEGEND

(1) Forest and Maquis climax. Main plant associations: *Quercus calliprinos — Pistacia palaestina* assoc., *Pinus halepensis — Hypericum serpyllifolium* assoc., *Cistetum villosi, Poterietum spinosi, Carthamus tenuis — Ononis leiosperma* assoc. (segetal), *Ononis leiosperma—Phlomis orientalis* assoc. (segetal)

(2) *Quercus calliprinos—Juniperus phoenicea* Maquis

(3) *Quercetum ithaburense* climax. Comprising Batha and segetal assoc.

(4) *Salvia dominica — Ballota undulata* assoc. and its variants on the hills, segetal *Ononis leiosperma—Phlomis pungens* assoc. with scattered *Crataegus azarolus* trees on plains and valleys

(5) *Pistacietum atlanticae* climax

(6) *Artemisietum herbae-albae* and its variants

(7) *Haloxylon articulatum—Salsola villosa* assoc.

(8) *Zizyphetum loti*

(9) *Retama duriaei—Rhus tripartita* assoc. on hard rocks

(10) *Anabasidetum articulatae* and several other Saharo-Sindian dwarf shrub associations in the Hammada area of E. Transjordan.

(11) *Anabasidetum articulatae* and its subassoc. *Acacietosum* in the Hammada area of W. 'Araba

(12) *Anabasis articulata—Zilla spinosa* assoc. and subassoc. *Noëtosum mucronatae* on Nubian sand

(13) *Haloxylonetum salicornici* and *Haloxylonetum persici*, mainly on granite sand

(14) Nubian sandstone along the steep eastern shore of the Dead Sea and along the eastern edge of W. 'Araba. Vegetation scarcely known

(15) *Nerion oleandri* and *Retametum roetami* in deep ravines of the rivers Zerqa, Arnon and Zered

(16) Oases with the *Zizyphus spina-christi — Balanites aegyptiaca* assoc., *Zizyphus spina-christi—Moringa aptera* assoc., *Acacietum alb/dae*, etc.

(17) Dry and wet salines with *Atriplicetum halimi, Salsoletum tetrandrae, Nitrarietum retusae, Suaedetum palaestinae*, etc.

LAKE KINNERETH
UM QEIS
IRBID
RAMTHA
MAFRAQ
AJLUN
KUFRINJE
JARASH
ZARQA
SALT
MAHIS
AMMAN
MUWAQQAR
QASR EL KHERANE
MADABA
JIZA
QALAT ED DEBA
DIBAN
DEAD SEA
EL QATRANE
KARAK
GHOR ES SAFI
TAFILE
QALAT EL HASA
BOSEIRA
JURF EL DARWISH
SHAUBEK
PETRA
WADI MUSA
MAAN
KUWEIRA
AQABA

NOUVELLE CONTRIBUTION A LA CONNAISSANCE DES DEUTEROMYCETES DE PALESTINE

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ABSTRACT

In this further contribution to the knowledge of Palestine Fungi notes are given on 50 species of Deuteromycetes (Fungi Imperfecti); most of them are new records for this country.

Some of these fungi have been isolated from the air; others were collected in mushroom beds, where they spread rapidly, affecting the normal growth of mushrooms or attacking their mycelium. Yet the majority are parasites on higher plants, some of which are new hosts to the given fungus or are of a peculiar phytogeographical interest, as *Polygonum acuminatum* Kth., of tropical distribution, which bears the same parasites in the Hula region as in the marshes of Argentine: *Cercospora paludicola* Speg. and *Ustilago cordai* Liro.

Two new species and one new variety are described, namely:

1) *Septoria* **withaniae** Rayss, sp. nov. — on *Withania somnifera* (L.) Dun.
2) *Cercosporina* **hierosolymitana** Rayss, sp. nov. — on *Salvia hierosolymitana* Boiss.
3) *Cercospora rhagadioli* Bubak var. **palaestina** Rayss, var. nov. — on *Rhagadiolus stellatus* (L.) Willd.

Depuis une vingtaine d'années nous poursuivons l'étude systématique des Champignons de notre pays, en récoltant beaucoup de matériel mycologique et en étudiant d'une façon consécutive en particulier les Micromycètes. Les résultats de cette étude ont fait l'objet d'une série de publications dont chacune s'occupe d'un groupe particulier de champignons et complète ainsi ce qui a été publié par nous préalablement sur ce même groupe. C'est ainsi que nous avons consacré quelques publications à des Urédinées, deux à des Ustilaginées, trois aux Archimycètes et Phycomycètes, trois aux Ascomycètes et trois aux Deutéromycètes.

Cette nouvelle contribution complète ce que nous avons déjà publié sur les Deutéromycètes et s'occupe de 50 espèces dont huit ont été indiquées par nous préalablement sur d'autres plantes hospitalières (voir la note au bas de la page 38). Les autres 42 figurent ici pour la première fois et avec 631 champignons que nous avons étudiés dans nos publications antécédentes, le nombre de Micromycètes indiqués par nous jusqu'à présent en Palestine remonte à 673.

Dans le présent travail nous nous occupons d'un certain nombre de Deutéromycètes parus dans les champignonnières et qui causent des pertes plus ou moins graves à la culture du champignon de couche, culture qui se développe ces derniers temps dans notre pays avec beaucoup de succès; quelques-unes de nos espèces ont été isolées du sol ou de l'air; les autres sont parasites sur différentes plantes hospitalières dont quelques-unes sont nouvelles ou d'un intérêt phytogéographique particulier, comme par exemple *Polygonum acuminatum* Kth., plante à répartition géographique tropicale, qui porte chez nous les mêmes parasites qu'en Argentine: *Cercospora paludicola* Speg. et *Ustilago cordai* Liro.

Dans la présente publication nous décrivons deux espèces et une variété nouvelles pour la science, à savoir:

Septoria withaniae Rayss, sp. nov.—sur *Withania somnifera* (L.) Dun.

Received July 1, 1955.

Cercosporina hierosolymitana Rayss, sp. nov. — sur *Salvia hierosolymitana* Boiss.
Cercospora rhagadioli Bubak var. *palaestina* Rayss, var. nov. — sur *Rhagadiolus stellatus* (L.) Willd.

PARTIE SPECIALE

SPHAEROPSIDALES

SPHEARIOIDACEAE

1. *Phyllosticta pirina* Sacc.

Sur les feuilles de *Pirus malus* L. SH: *) Holon, 27.IX.1954, coll. H. Chabelska. Taches épiphylles, plus ou moins rondes, blanches, bordées de brun, tombant en entier et laissant des perforations dans les feuilles rappelant celles produites par *Cercospora circumscissa*. Les taches sont quelquefois confluentes. Pycnides ponctiformes, lenticulaires, à pore ostiolaire bien évident, 120 — 140 μ de diam.; paroi de la pycnide roux — foncé, aux cellules larges. Spores elliptiques — allongées, hyalines, 4 — 5 × 1, 5 — 2. 5 μ.

2(I). *Cicinnobolus cesatii* de Bary**

Sur *Oidium dianthi* Jacz. parasitant les feuilles de *Dianthus multipunctatus*. S: Hadera, 20.III. 1951. Pycnides 40 — 58 × 19 — 30 μ se développant surtout dans des conidies terminales de l'*Oidium;* spores: 4 — 7 × 1. 5 — 3 μ. Les dimensions de nos pycnides dépassent les valeurs typiques indiquées pour cette espèce (25 — 35 × 9 — 15 μ) mais se rapprochent de celles indiquées par Diedicke (cf. Grove, 1935): 25 — 60 × 10 — 25 μ. Les dimensions des spores indiquées dans la diagnose sont aussi plus petites (2. 5 — 3 × 1 μ); chez Diedecke: 5 — 10 × 2 — 4 μ.

3. *Ceuthospora evonymi* Grove

Sur les feuilles mortes d'*Euonymus iaponicus* L., encore attachées aux branches. J: Jérusalem, 20. II. 1954, coll. H. Chabelska. Forme de nombreux points noirs sur fond blanc, tantôt sur une face de la feuille, tantôt sur l'autre. Stromata enfoncés dans le tissu de la feuille, 200 — 400 μ de diam. lorsqu'ils sont uniloculaires, 400 — 520 μ lorsqu'ils contiennent deux ou trois loges. Les conidies sortent en masses plus ou moins compactes, sont hyalines, droites, légèrement amincies à un bout, 10 — 16 × 2 — 2, 5 μ.

4 (I). *Ascochyta pisi* Lib.

Sur les feuilles de *Lathyrus ochrus* (L.) DC. CA: Yaaroth-Hacarmel, 30. III. 1949; en compagnie d'un *Cercospora*. Pycnides: 150 — 156 μ de diam.; spores: 14 — 15 × 4 — 5 μ. Ce champignon a été indiqué sur cette matrice au Chypre (Nattrass, 1937).

5. *Ascochyta sonchi* Grove

Sur les feuilles de *Sonchus oleraceus* L. UG: Hanita, 5. II. 1955. Taches arrondies ou anguleuses, 8 — 12 mm de diam., brun — fauve avec une bordure étroite brun foncé. Pycnides: 100 — 110 μ de diam., avec un large ostiole au centre (20μ); spores droites ou courbées, hyalines, pourvues d'une cloison transversale, 8 — 11 × 3 — 4 μ, avec une gouttelette au centre de chaque cellule. Correspond entièrement à la diagnose de Grove, mais nos spores sont un peu plus larges (dimensions indiquées par Grove: 8 — 10 × 2 — 3 μ).

6 (I, II). *Darluca filum* (Bivon.) Castagne

Dans les urédosores de *Puccinia romagnoliana* Maire et Sacc. parasitant *Cyperus rotundus*. HP: marécages de Houleh, 29. V. 1951. Pycnides: 100 — 120 μ de diam.; spores: 10 — 15 × 3 — 4 μ, bicellulaires.

7. *Septoria ari* Desm.

Sur les feuilles d'*Arum hygrophilum* Boiss. (En compagnie de *Colletotrichum montemartini*). UG: mont Jermak, 10. VI. 1951, coll. N. Feinbrun. Pycnides: 75 — 120 μ de diam.; spores: 15 — 45 × 1,5 — 2,5 μ. Plante hospitalière nouvelle ?

* Pour faciliter l'orientation dans les localités que nous citons dans ce travail, nous avons désigné les régions de Palestine par les abbréviations suivantes: AP—plaine d'Acre; CA—chaine du Carmel; HP—plaine de Houleh; J—montagnes de Judée; LG — basse Galilée; S — Saron; SH — Shefela; UG — haute Galilée.

** Les chiffres romains (I) et (II), placés après le numéro d'ordre, se rapportent respectivement à deux de nos publications antérieures; (I) — Rayss, 1943; (II) — Rayss, 1950, ou l'espèce en question a été déjà indiquée par nous en Palestine mais sur une autre plante hospitalière.

8. *Septoria coniicola* Hollos

Sur les feuilles fanées de *Conium maculatum* L. J: Aquabella, 21. I. 1951. Pycnides: 100 — 150 μ de diam.; conidies filiformes, 28 — 50 × 1 — 2 μ. Cette espèce diffère de *Septoria conii* Syd. par les dimensions plus grandes de ses pycnides et de ses spores. Le diamètre de nos pycnides dépasse même les valeurs indiquées par Hollôs (70 — 100 μ).

9. *Septoria gladioli* Passer.

Sur les feuilles de *Gladiolus atroviolaceus* Boiss. J: Deir-Amar, 8. V. 1951. Pycnides: 84 — 108 μ de diam.; spores: 31 — 45 × 2.5 — 3 μ.

10. *Septoria iridina* Sacc.

Sur les feuilles d'*Iris sisyrinchium* L. J: Deir-Amar, 15. III. 1951. Pycnides: 65 — 86 μ de diam. (dans la diagnose: 100 — 120 μ), disposées au centre de taches circulaires — elliptiques, 1—2 mm de diam.; spores: 10 — 21 × 1 — 1.5 μ, hyalines, souvent un peu courbées. Ce champignon a été décrit au Portugal sur les feuilles d'*Iris foetidissima* et, à notre connaissance, n'a pas encore été indiqué sur *Iris sisyrinchium*. *S. iridina* diffère de *S. iridis* Massalongo (que nous avons trouvé en Palestine (Rayss, 1943) sur *Iris haynei*, *I. nazarena* et *I. lorteti*) par ses spores plus petites et plus minces (spores de *S. iridis:* 20—32 x 4—5 μ dans la diagnose de Massalongo et dans nos exemplaires: 15—35 × 3—5 μ).

11. *Septoria silybi* Passer.

Sur les feuilles de *Silybum marianum* (L.) Gaertn. CA: Zikhron — Ya'acob, 15. III. 1951; Haifa — Carmel, 10. III. 1949. Taches de couleur gris-brunâtre, luisantes: 60 — 150 μ de diam.; spores: 50 — 75 × 2 — 2.5μ.

12. *Septoria* **withaniae** Rayss sp. nov.

Maculis amphigenis, 1-2 mm diam., rotundatis vel irregularibus, albidis, arescentibus, margine perspicuo elevato obscure purpureo praeditis; pycnidiis epiphyllis paucis, immersis, brunneis, 90-130 diam., ostiolo minuto pertusis; sporulis filiformibus, hyalinis, rectis vel curvulis, 18-40 × 1,5-2-5μ, continuis vel 1-3 septatis.

Habitat in foliis vivis *Withaniae somniferae* (L.) Dun: Palaestina, SH: Ramleh 20. II. 1949.

Aucune espèce de *Septoria* n'a été indiquée, à notre connaissance, ni sur les *Withania*, ni sur le genre voisin, *Atropa*.

13 (II). *Stagonospora iridis* C. Massolongo

Sur les feuilles d'*Iris sisyrinchium* L. S: Kabbara, 20. III. 1951. Plante hospitalière nouvelle? S: Pycnides: 108-120μ, pourvues d'un large ostiole, disposées en groupes compacts au milieu de taches noirâtres, opaques, plus claires en section. Spores hyalines, 28-45 × 4-6μ, droites ou un peu courbées, avec des gouttelettes d'huile au début, formant plus tard une ou deux cloisons transversales. Ce champignon a été indiqué par nous sur *Iris mesopotamica* Dykes.

14. *Microdiplodia agni-casti* Sacc.

Sur les tiges de *Vitex agnus-castus* L. CA: Daliyah, 29. V. 1949. Pycnides ponctiformes, rompant l'épiderme par leur pore proéminent, 110-150μ de diam.; spores: 8-10 × 4-5μ, fuligineuses, pointues aux deux extrémités.

15. *Microdiplodia melaspora* (Berk.) Griff. et Maublanc

Sur les feuilles sèches de *Saccharum biflorum* Forsk. SH: Tel-Aviv, bords du Yarkon, 4. IX. 1951. Pycnides: 180-300μ de diam.; spores: 7-11 × 5-6μ, très foncées, munies d'une paroi transversale, pas retrécies en face de la cloison. Ce champignon est indiqué comme *Darluca melaspora* Berk. = *Coniothyrium melasporum* (Berk.) Sacc. en Australie et au Porto-Rico, sur *Saccharum officinarum*. Le *Saccharum biflorum* est probablement une plante hospitalière nouvelle.

16. *Microdiplodia palmarum* Died.

Sur les feuilles de *Phoenix dactylifera* L. (en compagnie de *Graphiola phoenicis*). S: Caesarea, 21. X. 1944. Les pycnides sont logées sous l'épiderme de la feuille, la soulèvent et la rompent avec le temps; spores ovoïdes, brunes, d'abord continues, ensuite bicellulaires, 8-11 × 4-4,5μ.

MELANCONIALES

MELANCONIACEAE

17. *Cryptosporium phillyreae* Pat.

Sur les feuilles mortes de *Phillyrea media* L. UG: mont Jermak, 25. III. 1955, coll. H. Chabelska et Sh. Borut. Acervules en groupes nombreux, amphigènes, au début recouverts par l'épiderme; ils la rompent ensuite par une fente et forment à la fin des faux-conceptacles entourés par l'épiderme à leur base, noirs, charbonneux, 200-250 × 150-165μ. Conidies hyalines, continues, filiformes, avec des gouttelettes d'huile, 12-18 × 1,5 2μ.

18. *Cylindrosporium myosotidis* Sacc.

Sur les feuilles de *Symphytum palaestinum* Boiss. (associé à l'*Entyloma serotinum* Schröt.) J: Ain-Karem, 11. IV. 1955, coll. H. Chabelska. Taches amphigènes, pâles au début devenant jaunâtres par la suite, 1-3 mm de diam. quelquefois confluentes, tombant et laissant dans les feuilles des perforations rondes analogues à celles laissées par *Cercospora circumscissa*. Conidiophores hypophylles; conidies hyalines, un peu courbées, 30-50 × 1,5-2,5μ, contenant plusieurs gouttelettes d'huile ou indistinctement cloisonnées. Plante hospitalière nouvelle.

19. *Cylindrosporium salviifolii* Bernaux

Sur les feuilles de *Cistus salviifolius* L. J: Beth-Meir, 6. II. 1952. Taches arrondies, de couleur violet-rougeâtre, 1-2 mm de diam.; conidies: 25-55 × 1,5-2μ, hyalines, flexueuses, munies de 3 à 5 cloisons.

Sur les feuilles de *Cistus villosus* L. J: Kiryath-Anavim, 8. V. 19451. Plante hospitalière nouvelle ? Taches: 1-1,5 mm de diam.; conidies: 35-45 × 1,5-2μ.

Sur le *Cistus creticus* à Malte est décrit le *Cylindrosporium torquens* Sacc. (Syll. XXV: 621) qui forme sur les feuilles des taches plus petites que celles formées sur *Cistus salviifolius* et dont les conidies sont aussi plus petites ("38 × 2, interdum 28 × 2μ, vel brevioribus"). Les dimensions de notre champignon se rapprochent mais n'atteignent pas celles indiquées par Bernaux pour le *C. salviifolii* sur *Cistus salviifolius* de France (40-75 × 1,5-2μ). Les valeurs spécifiques de deux espèces de *Cylindrosporium* indiquées sur les *Cistus* devraient être vérifiées par voie expérimentale.

20. *Pestalotia* (*Pestalozzia*) *versicolor* Speg.

Isolé de l'air à Tel-Aviv, le 8. VII. 1954 par R. Barkaï-Golan. Forme sur l'agar des masses globuleuses-lenticulaires disposées en anneaux concentriques. Conidies formées par cinq cellules, droites ou un peu courbées, légèrement retrécies au niveau des cloisons, 23-30μ de longueur. Les loges médianes sont fortement colorées, l'inférieure plus claire, olivâtre; toutes sont remplies de gouttelettes d'huile et mesurent 16-18 × 7-8μ; les loges terminales sont hyalines, celle de l'apex portant trois, rarement quatre cils incolores, assez gros, largement divergents, 20-30μ de longueur. La cellule basale est allongée et portée par un pédicelle court (5-8μ).

Notre champignon correspond par tous ses caractères au. *P. versicolor* Speg. sensu str. qui, d'après Guba (1929), serait spécifique pour *Nerium oleander*. Nous avons confié la culture pure de ce champignon à Sh. Boneh-Borut qui en a fait une série d'infections artificielles sur les feuilles de plusieurs plantes, cultivées dans nos jardins. Les résultats de ces expériences sont publiés dans ce même journal (Sh. Boneh-Borut, 1955).

HYPHOMYCETES

MUCEDINACEAE

21. *Microstroma album* (Desm.) Sacc.

Sur les feuilles de *Quercus infectoria* Oliv. UG: Beth-Yan sur Jermak, 10. IV. 1951, coll. M. Zohary. Plante hospitalière nouvelle? Conidiophores en masse sur la face inférieure des feuilles, sous forme d'une massue allongée, 16-24×2-2,5μ. Conidies: 7-9 × 2,5-3,5μ, fusiformes, hyalines, contenant à l'intérieur 1-2 gouttelettes d'huile.

22. *Myceliophthora lutea* Cost.

Dans les champignonnières à Matsuba (UG), coll. S. Kohn le 10.XII. 1950; Beer-Ya'acov (SH), coll. J. Kovacs le 10. V. 1951; produit la maladie du "vert-de-gris" du champignon de couche. Conidies ovales, hyalines, 3-5 × 2μ, en courtes chaînettes; chlamydospores rondes, 6-7,5μ de diam., à membrane épaisse devenant jaune-brunâtre. Ce champignon se répand sur le sol avec une grande rapidité et affecte le mycélium du champignon de couche en entravant considérablement la formation de chapeaux. Nous avons envoyé notre matériel à Mme J. Nicot-Toulouse au Laboratoire de Cryptogamie du Muséum d'Histoire Naturelle à Paris qui a bien voulu revoir et confirmer notre détermination. Nous lui témoignons par cette voie notre reconnaissance.

23. *Myceliophthora sulfurea* Godard

SH: Ramath-Gan, dans les champignonnières, XII. 1952, coll. J. Kovacs; J: Nev'e-Ilan, I. 1953; UG: Matsuba, 1952, coll. S. Kohn. Dans ces trois champignonnières cette espèce s'est développée sur le mycélium d'une race brunâtre du champignon de couche recommandée comme plus résistante et dont le "blanc" a été importé d'Amérique; sans aucun doute le parasite a été importé avec le"blanc".

Ensemencé sur Czapek, le *M. sulfurea* développe un mycélium d'abord blanc, ensuite jaune-soufre, avec une bordure blanche. Les hyphes aériennes sont bien développées, cloisonnées et ramifiées, contenant de nombreuses bulles d'air, mais ne formant pas de conidies; quelquefois elles se fragmentent à la façon d'un *Geotrichum*. Le mycélium qui se développe dans le substratum est cloisonné, hyalin, 2-4μ de diam. et porte de nombreuses conidies de forme variable, 5-10 × 4-8μ. Parfois un filament entier se présente comme une chaînette d'*Oidium*, aux segments de grandeur et de forme variables. Dans les champignonnières il forme des masses floconneuses d'un blanc jaunâtre atteignant 10 cm de diam. qui soulèvent le compost et dégagent une odeur ammoniacale bien prononcée. Notre champignon correspond assez bien aux descriptions (assez sommaires) du *Myceliophthora sulfurea* Godard. On l'a énergiquement combattu et il n'a plus paru depuis.

24. *Monilia sitophila* (Mont.) Sacc.

SH: Tel-Aviv, isolé de l'air dans un moulin de vapeur par R. Barkaï-Golan, le 15. IV. 1951; UG: Matsuba, répandu dans les champignonnières, coll. S. Kohn. Forme sur agar un gazon de couleur rose-orange; hyphes cloisonnées, retrécies à l'endroit de la cloison transversale, ramifiées dichotomiquement, 100-140 × 8-14μ; conidies terminales, en chaînettes courtes, apiculées à leur base, 9-11μ de diam.

25. *Geotrichum candidum* Link

SH: Beer-Ya'acov, 10.I.1952, sur le fumier des meules dans les champignonnières, coll. J. Kovacs Hyphes mycéliennes, 5—6μ de diam. formant des endospores caractéristiques, 4—10 × 4—5μ. Ce champignon s'étend rapidement et recouvre par ses hyphes le mycélium du champignon de couche qui cesse de former des chapeaux. A l'aide d'une forte loupe binoculaire nous avons pu observer les calottes touffues du parasite sur les hyphes même du *Psalliota*, reconnaissables à cause des petits cristaux qui les recouvrent.

26. *Oedocephalum fimetarium* (Riess) Sacc.

UG: Matsuba, dans les champignonnières, coll. S. Kohn, le 1.I.1952. Conidiophores cylindriques dressés, cloisonnés, renflés à leur base et portant au sommet une vésicule capitée avec de courts

sterigmates, 3—4 de longueur, sur lesquels sont insérées les conidies; le diamètre de la vésicule: 20—28μ; avec des conidies sur place: 40μ. Conidies hyalines, ovoïdes, 6—13 × 3—10 μ, pour la plupart 7—8 × 3—5 μ. S. Kohn a observé que les conidies s'accolent en masse aux nématodes et probablement leur nuisent puisqu'on trouve beaucoup de nématodes morts aux endroits où pousse ce champignon. *O. fimetarium* est considéré comme une forme imparfaite de *Plicaria vesiculosa* Bull.

27 (I). *Botrytis cinerea* Pers. (sect. *Polyactis*)

UG: Matsuba, sur la terre dans les champignonnières, 10.VII.1951, isolé en culture pure par S. Kohn. Forme sur le milieu de culture un feutre gris-brunâtre. Conidiophores: 3—14 μ, rarement jusqu'à 26 μ de diam. Conidies insérées en grappes sur de petites verrues spinescentes disposées le long du conidiophore. Les conidies sont plus ou moins arrondies, 5—9 et jusqu'à 12 μ de diam., à membrane hyaline, devenant avec l'âge légèrement brunâtre.

Sur les jeunes tiges et les feuilles pourries d'*Allium cepa* L. J: Jérusalem, 20.II.1954, coll. M. Negbi. Conidiophores: 400—600 × 10—18 μ, sortant isolés ou par groupes de 2—3 par les stomates, ramifiés et portant en petits bouquets terminaux des conidies, rondes ou ovales, 8—12 × 6—8 μ.

Sur les tiges et les pétioles pourris de *Cyclamen coum* Mill. en culture. J: Jérusalem, 25.II.1953, coll. Z. Bumstein. Conidiophores: 750—1000 × 17—25 μ; conidies: 10—15 × 7—10 μ.

Sur les feuilles pourries de *Lactuca sativa* L. J: Jérusalem, 15.III.1953, coll. J. Kirstein. Conidiophores: 1000—1700 × 12—20 μ; conidies: 7—18 × 6—8 μ, ovales, lisses.

Sur les feuilles pourrissantes de *Solanum tuberosum* L. J: Jérusalem, 10.III.1953, coll. M. Negbi. Conidiophores: 1000—1500 × 15—20 μ; conidies: 8—12 × 7—8 μ.

28. *Sepedonium chrysospermum* (Bull.) Fries

UG: Matsuba, sur la terre et les tiges pourries dans le compost des champignonnières, isolé le 29.XII.1952, par S. Kohn. Mycélium blanc au début, devenant avec le temps jaune d'or, ramifié, cloisonné. Diam. des hyphes: 3—5 μ. Chlamydospores acrogènes, 12—17 μ de diam., entourées d'une membrane épaisse ornée par des verrues distantes.

Ce champignon, fréquent sur divers Hyménomycètes en Europe, n'a pas encore été trouvé par nous sur les champignons de nos forêts; il est possible que celui de Matsuba fut importé d'Amérique avec le "blanc" des semis. Toutefois nous n'avons pas constaté qu'il attaque les chapeaux du champignon de couche. *S. chrysospermum* est considéré être le stade chlamydospore de l'*Hypomyces chrysospermus* Tul.

29. *Sepedonium xylogenum* Sacc.

SH: Tel-Aviv, isolé de l'air par R. Barkaï-Golan, le 25.I.1954. Forme sur Agar-Czapek des colonies blanches étendues. Hyphes hyalines, secrétant de nombreuses gouttelettes et pourvues de cloisons transversales en petit nombre. Conidiophores: 4—9 μ de diam.; conidies terminales, rondes, hyalines, recouvertes d'aspérités, 15—20 μ de diam. Ce champignon a été indiqué en Italie sur le bois pourrissant.

30 (I). *Ramularia anchusae* Massal.

Sur les feuilles d'*Anchusa hybrida* Ten. S: Pardess-Hanna, 8.III.1951, coll. N. Feinbrun. Conidiophores: 45—60 μ (rarement jusqu'à 90 μ) × 3—4,5 μ; conidies: 25—42 × 4—5 μ, avec une ou deux cloisons transversales.

31. *Ramularia didymarioides* Briosi et Sacc.

Sur les feuilles de *Silene inflata* DC. J: Jérusalem, 18.IV.1954, coll. H. Chabelska. Taches circulaires sur les deux faces de la feuille; conidiophores allongés, flexueux, hyalins, 70—100 × 4—5 μ; conidies cylindriques, 15—30 × 6—10 μ, arrondies aux extrémités, hyalines, continues ou portant une, rarement deux cloisons transversales. Les conidies de nos échantillons sont un peu plus courtes que ne l'indique la diagnose (26—36 × 6—9 μ); par contre, les conidiophores rentrent dans les limites de la diagnose (60—100 × 4—5 μ), mais n'atteignent pas les valeurs indiquées pour ce champignon en Roumanie: 75—220 × 3—4 μ (cf. Herbarium Mycologicum Romanicum, XXVIII, No. 1390).

32. *Ramularia menthicola* Sacc.

Sur les feuilles de *Mentha silvestris* L. AP: Kabri, 27.III.1950. Taches petites et rondes. Conidiophores: 36—60 × 4—5,5 μ; conidies cylindriques, en chaînettes très courtes, au début continues, ensuite bicellulaires, hyalines, 18—33 × 3,5—4 μ.

33. *Ramularia oxalidis* Farlow

Sur les feuilles d'*Oxalis violacea* L., cultivé dans les serres de l'Institut Botanique à Jérusalem et originaire de l'Amérique du Nord, coll. Z. Bumstein 15—VII.1954. Taches amphigènes, circulaires; conidiophores hyalins, 35—70 × 3—4 μ; conidies continues ou bicellulaires, hyalines, cylindriques, atténuées aux deux extrémités, 10—28 × 3—4 μ. Ce champignon paraît être connu jusqu'à présent seulement d'Amérique (Sacc., Syll. IV.204).

DEMATIACEAE

34 (I). *Fusicladium depressum* (B. et Br.) Sacc.

Sur les feuilles et les tiges de *Foeniculum vulgare* Mill. J: Jérusalem, 5.IV.1955. Conidiophores: 60—80 × 5—7 μ; conidies: 25—45 × 6—8 μ.

35. *Helminthosporium anomalum* Gilman et Abbott

SH: Tel-Aviv, isolé de l'air par R. Barkaï-Golan, le 3.VIII.1954. Forme sur Czapek des colonies veloutées, à croissance assez lente. Hyphes d'abord submergées dans le milieu de culture, ensuite aériennes, multiseptées, d'un brun foncé. Conidiophores: 200—400 μ de longueur, plus ou moins courbés; conidies allongées, droites, arrondies au bout, pourvues de 5 à 10 cloisons transversales, 50—90 x 12—16 μ. Cette espèce a été isolée du sol aux Etats Unis.

36 (I). *Cercospora apii* Fresen.

Sur les feuilles d'*Apium graveolens* L. J: Jérusalem, 16.III.1955. Taches amphigènes, plus ou moins rondes, 4—6 mm de diam.; conidiophores: 60—70 × 5—7 μ (dans la diagnose: 40—60 × 4—5 μ); conidies: 45—60 × 2—4 μ, avec plusieurs cloisons transversales.

37. *Cercospora ceratoniae* Pavill. et Trab.

Sur les feuilles de *Ceratonia siliqua* L. SH: Hulda, 26.I.1951, coll. Z. Eliash. Conidies: 30—43 × 2,5—3 μ, pourvues de 2—3 cloisons transversales.

38. *Cercospora dubia* (Riess) Bubak

Sur les feuilles d'*Atriplex patula* L. AP: Saint-Jean d'Acre, marécages salés, 22.VI.1951, coll. D. Zohary. Conidiophores: 48—53 × 3,5—6,5 μ; conidies: 24—43 × 5—7 μ, pourvues de 2 ou 3 cloisons transversales. Les cellules médianes sont renflées et plus larges que les cellules terminales.

Sur les feuilles de *Chenopodium murale* L. S: Pardess-Hanna, 8.III.1955. Taches circulaires, amphigènes, atteignant 0,5 cm de diam.; conidiophores de deux côtés de la feuille, 20—50 × 4—6 μ, sous forme de bâtonnets non ramifiés, continus, de couleur olivâtre, sortant pour la plupart par les stomates; conidies terminales, un peu courbées, 32—45 × 5—9 μ, avec 3—4 cloisons transversales, un peu retrécies à l'endroit des cloisons. Notre champignon diffère un peu de la diagnose de Bubak (Cf. Lindau, 1910 p. 800) par les dimensions plus petites de ses conidiophores et de ses conidies (dans la diagnose: conidiophores: 45—62 × 4,5—6,5 μ; conidies: 38—55 × 4,5—7 μ).

39. *Cercospora dulcamaricola* Hollos

Sur les feuilles de *Solanum villosum* (L.) Lam.

S: Gan Shmuel, 28.VII.1951; Wadi Falik, 4.IX.1951. Plante hospitalière nouvelle. Taches arrondies, brunâtres, se desséchant au centre, bordées de brun; houppes conidifères de deux côtés de la feuille. Conidiophores brunâtres, non ramifiés, pourvus d'une ou deux cloisons transversales, courbés, 30—35 × 4—4,5 μ; conidies cylindriques, à partie basilaire élargie et partie apicale s'amincissant

progressivement, droites ou courbées, 40—100 × 4—5 μ, divisées par 5—9 cloisons transversales. Sur les *Solanum* sont indiquées plusieurs espèces de *Cercospora;* notre champignon correspond le mieux au *C. dulcamaricola*, décrit par Hollós en Hongrie sur les feuilles flétries de *Solanum dulcamara.*

40. *Cercospora handelii* Bubak

Sur les feuilles de *Rhododendron* (*Azalea*) *sp.*, cultivé dans la serre de l'Université Hébraïque à Jérusalem, coll. H. Chabelska le 30.IX.1954. Taches ocracées, sèches, limitées dans leur extension par les nervures de la feuille. Houppes conidifères pour la plupart épiphylles (dans la diagnose — hypophylles) et sortent d'un tubercule sclérotiforme sous — épidermal en fascicules denses. Conidiophores isolés presque hyalins, d'un olive-brunâtre quand ils sont serrés; ils sont cloisonnés, denticulés au sommet, 25—35 × 2,5—4 μ. Conidies: 48—85 × 3—4 μ, obtuses aux deux extrémités, courbées, olivâtres, pourvues de gouttelettes d'huile et souvent portant jusqu'à 7 cloisons transversales.

Nous avons déterminé notre champignon comme *C. handelii* et pas comme *C. rhododendri* (transféré récemment au genre *Cercosporina*), parce que les conidies de notre champignon ont en masse la couleur olivâtre (pas hyalines comme chez *C. rhododendri*) et sont quelquefois divisées par des cloisons (et pas continues, comme chez *C. rhododendri*).

41. *Cercospora paludicola* Speg.

Sur les feuilles de *Polygonum acuminatum* Kth. HP: bords du lac Houleh, 19.II.1955. Taches amphigènes, 2—3 mm de diam., anguleuses, limitées par les nervures des feuilles, brun foncé; conidiophores 40—50 × 3—4,5 μ, cylindriques, olivacés, noduleux; pour la plupart sur la face inférieure de la feuille, mais se trouvent en moindre quantité et moins bien développés aussi sur la face supérieure; conidies bacillaires, claviformes, un peu courbées, 28—130 × 3—5 μ, au contenu granuleux, quelquefois avec 5—7 cloisons transversales bien visibles. Notre champignon diffère de tous les *Cercospora* décrits sur les *Polygonum* par ses conidies très longues et par ce caractère, comme par tous les autres aussi, correspond au *C. paludicola* décrit sur les *Polygonum* dans les marécages d'Argentine. La seule différence—la largeur des conidies qui est dans nos exemplaires 3—5 μ et dans la diagnose 3—3,5 μ. Rappelons que nous avons déjà trouvé sur *Polygonum acuminatum* de Houleh l'*Ustilago cordai* Liro, ad interim (Rayss, 1952) avec les mêmes caractères que ce champignon manifeste en Argentine et au Brésil, à savoir, spores notablement plus foncées (cf. Liro, 1924). Le *Polygonum acuminatum* est une plante à répartition géographique tropicale et se trouve chez nous avec les mêmes maladies qu'en Argentine. Nous avons trouvé au Houleh, des plantes qui portaient sur leurs feuilles les taches de *Cercospora paludicola* et dans leurs inflorescences — l'*Ustilago cordai.*

42. *Cercospora plantaginis* Sacc.

Sur les feuilles de *Plantago major* L. AP: Nahariya, 28.V.1949. Taches amphigènes, bordées de brun; leur partie centrale se dessèche souvent et tombe, en laissant dans la feuille des trous ronds, pareils à ceux formés par *Cercospora circumscissa.* Conidiophores: 35—53 × 3—4 μ; conidies: 80—115 × 3—4μ aux nombreuses cloisons transversales.

43. *Cercospora punctiformis* Sacc. et Roum.

Sur les feuilles de *Cynachum acutum* L. HP: bords du Jourdain au nord du lac Houleh, 30.V.1951. Taches amphigènes, jaunâtres, blanchissant au centre; conidiophores le plus souvent épiphylles, 35—50 × 4—5 μ, tortueux, continus ou pourvus d'une cloison indistincte; conidies: 35—70 × 3—4 μ, à 3—6 cloisons transversales.

Sur les mêmes taches on trouve rarement, aux endroits où le mésophylle a été presqu'entièrement détruit, des conidiophores d'un *Cercospora* qui atteignent 100 μ de longueur et sont cloisonnés, rappelant ceux de *C. bellynckii* (West.) Sacc. Mais c'est plutôt une exception et nous n'avons pas pu élucider s'il s'agit de deux espèces de *Cercospora* sur la même plante hospitalière (les deux champignons ont été indiqués sur cette matrice) ou si c'est une forme aberrante du *C. punctiformis.* Nous avons déterminé notre champignon comme *C. punctiformis* puisqu'il forme des taches caractéristiques sur les feuilles (le *C. bellynckii* n'en forme pas), puisque les conidiophores dans nos exemplaires sont plutôt épiphylles (et pas diffus sur la face inférieure de la feuille) et grâce à la forme et la grandeur de nos conidiophores typiques ne ressemblant nullement à ceux du *C. bellynckii* (dont la figure est reproduite chez Lindau, 1910, p. 129).

44. *Cercospora rhagadioli* Bubak var. **palaestina** Rayss, var. nov.

Sur les feuilles de *Rhagadiolus stellatus* (L.) Willd. J: Deir Amar, 15.III.1951. Taches arrondies, brunes, portant des conidiophores sur leurs deux faces (et non seulement sur la face inférieure, comme il est indiqué dans la diagnose); conidiophores longs, onduleux, çà et là cloisonnés, de couleur brunâtre, 60—130 μ (même jusqu'à 180 μ) de longueur, 3—5 μ de diam. (dans la diagnose: conidiophores continus, 30—45 × 3,5—6,5 μ); conidies: 55—170 (et même jusqu'à 216 μ) × 2,5—3,5 μ (dans la diagnose: 50—90 × 2,5—3,5 μ), filiformes, hyalines, droites ou courbées, à quelques cloisons transversales souvent indistinctes.

Notre variété se distingue de la forme typique par ses conidiophores cloisonnés, disposés sur les deux faces de la feuille, de même que pour les dimensions plus grandes des conidiophores et des conidies.

45. *Cercosporina* **hierosolymitana** Rayss, sp. nov.

Maculis amphigenis, angulosis vel rotundo-irregularibus, subinde confluentibus, 1,5—5 mm diam. superne obscure fuligineis, inferne atro-brunneis, nitidioribus; conidiophoris amphigenis caespitosis, 5—10 in quoque fascicolo, basi brunneis, apicem versus pallidioribus, geniculatis, 1—3 septatis; conidiis hyalinis, 5—8 septatis, rectis vel curvis, basi truncatis supra attenuatis, 45—115 × 2—4 μ. Habitat in foliis vivis *Salviae hierosolymitanae* Boiss. Palaestina: J: Jérusalem, 16.XI.1951; LG: Tiv'on, 16.IV.1951. Sur différentes espèces de *Salvia* ont été décrits trois champignons du groupe de *Cercospora*, tous les trois en Amérique: *Cercospora papillosa*, *Cercosporella salviae* et *Cercosporina salviicola*, Notre champignon ressemble le plus au *Cercosporina salviicola* (Thasp) Sacc. décrit sur *Salvia farinacea* en Amérique boréale, mais il en diffère, en dehors de la plante hospitalière et sa distribution géographique, par la couleur et la forme de ses taches et les dimensions de ses conidiophores et de ses conidies.

46. *Macrosporium trichellum* Arc. et Sacc.

Sur les feuilles d'*Euonymus japonicus* L. J: Jérusalem, 20.II.1954, coll. H. Chabelska. Forme sur les feuilles des taches larges, sèches, entourées d'une marge brune. Conidiophores de deux côtés de la feuille (pas épiphylles comme l'indique la diagnose pour ce même champignon parasitant *Lonicera tatarica*); ils sont tortueux et aboutissent à une configuration hélicoïdale rappelant celle des *Polythrincium;* leurs dimensions sont: 80—90 μ (rarement jusqu'à 100 μ) × 4—8 μ. Conidies apicales, obovales ou sous forme de tonnelets, avec 3—4 cloisons transversales et 0—2—3 cloisons longitudinales, 26—32 × 15—20 μ.

47. *Alternaria citri* Pierce

Sur les feuilles de *Citrus limon* Burm. f. J: Jérusalem, 10.V.1955, coll. Sh. Borut. Forme sur les bords des feuilles des taches irrégulières brun clair sur lesquelles on peut voir de petits points noirâtres—chaînettes de conidies d'*Alternaria*. Ces conidies sont au début elliptiques-oblongues, 15—25 × 4—12 μ, pour la plupart pourvues de trois cloisons; apparaissent ensuite des conidies oblongues claviformes, avec 4—7 cloisons transversales et quelques cloisons longitudinales, d'un brun foncé-noirâtre, 30—42 × 12—16 μ (dans la diagnose: 25—40 × 15—25 μ, mais nos conidies ne sont pas si larges). Le champignon a été isolé en culture pure par Sh. Boneh—Borut et la réinfection des feuilles de *Citrus limon* a réussi sur les deux faces de la feuille, seulement après une lésion préalable. Ce champignon qui est répandu un peu partout dans les plantations d'agrumes, attaque généralement les fruits et cause quelquefois des dommages considérables. Il a été indiqué sur les feuilles de *Citrus limon* à Chypre (Nattrass 1937) et au Maroc (Maire et Werner (1937); il a été isolé en Israël des oranges Shamouti (Minz, 1946). En Italie, est en outre indiqué sur les pétales et les étamines de *Citrus aurantium* et *C. limon* l'*Alternaria brassicae* (Berk.) Sacc. f. *citri* Penzig, mais ses conidies sont plus grandes: 60—70 × 14—18 μ (Ferraris, 1907, p. 522). Par la dimension de ses conidies notre champignon se rapproche davantage de l'*A. tenuis* Nees f. *genuina*, espèce saprophyte et très commune vivant sur les milieux de culture les plus divers et sur un grand nombre de plantes hospitalières (y compris *Citrus*). Mais la forme des conidies est différente: elle sont lagéniformes ou muriformes chez *A. tenuis*, terminées par un rostre de forme et de grandeur variables, possèdent 3 à 5 cloisons et sont retrécies à l'endroit des cloisons. La forme *chalaroides* Sacc. de l'*A. tenuis* qui a été trouvée dans les fruits de *Citrus deliciosa* en Italie ne ressemble pas du tout à notre champignon.

TUBERCULARIACEAE

48. *Epicoccum humicola* (Buchanam) Sacc.

Apparu comme infection sur le milieu de culture renfermant le levain au Laboratoire du Prof. Hestrin. J: Jérusalem, 21.I.1955, leg. Gad Avigad. Cultivé sur Agar-Czapek, forme des hyphes hyalines à l'intérieur de l'agar et au pourtour des colonies; les hyphes aériennes deviennent roses avec nuance orange et passent avec l'âge au cinabre; chaque colonie est en outre entourée d'une bordure brune devenant violette. Les hyphes sont cloisonnées, ramifiées; le stroma-orbiculaire, brun, 150—450 μ de diam.; conidies sphériques ou ovales, de structure alvéolaire, 12—30 × 12—28 μ (dans la diagnose: 10—25 μ), verruqueuses, brun-noirâtre, devenant noires avec l'âge, quelquefois portées par un très court pédicelle hyalin (diagnose: "non stipitatis").

Cette espèce a été décrite en Amérique boréale "in agaro-dextrosio pulvere terrae humosae infecto" (Saccardo, XXV, p. 985). Notre champignon lui correspond par tous ses caractères, toutefois ses spores sont un peu plus grandes (12—30 et pas 10—25 μ). Il ressemble aussi à l'*Epicoccum reticulatum* Cooke trouvé par nous précédemment à Jérusalem (Rayss, 1950), mais ce dernier forme des colonies brun-noir et ne fait jamais jouer une si belle gamme de couleurs sur le même milieu de culture.

MYCELIA STERILIA

49. *Papulospora byssina* Hotson

Sur les meules des champignonnières. SH: Be'er Ya'acov, 20.IX.1951, coll. J. Kovacs; J: Neve-Ilan, 23.IV.1954, coll. A. Hartani. Bulbilles allongées, de couleur blanc-crème ou jaune-paille devenant brunâtre, 75—250 μ de diam., composées de cellules hexagonales, 8—15 × 6—10 μ; diamètre des hyphes: 3—4 μ. Forme des taches rondes sur les meules qui s'étendent rapidement dans toutes les directions. Cause la maladie appelée "Plâtre brun" et est souvent indiqué sous le nom de *Myriococcum praecox* Fr.

50. *Sclerotium stercorarium* DC.

Sur les excréments des vaches maintenus dans des boites fermées, J: Jérusalem, 20.II.1953. Les sclérotes ont 8 à 10 mm de diam., atteignent la grandeur d'un grain de pois et sont noirs à l'extérieur et blancs en section. Dans les mêmes boites s'est developpé ensuite le *Coprinus stercorarius* Fr. ex Bull. *Sclerotium stercorarium* pourrait être un stade dans le développement de ce coprin (Lindau 1910, p. 666).

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A CONTRIBUTION TO THE BRYOPHYTIC FLORA OF PALESTINE

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ABSTRACT

An annotated list comprising 131 mosses, fifty apparently new to the Eastern Mediterranean, with numerous range extensions of mosses in desert and semi-desert areas. Includes descriptions of *Tortula* **israelis** Bizot et Bilewsky sp. n., *Ephemerum sessile* (Br. et Schpr.) C. Muell. var. **kushniri** Bizot var. n. and *Philonotis laxissima* (C. Muell.) Br. eur. var. **gemmiclada** Bizot var. n.

The bryophytic flora of Palestine has not as yet been adequately studied. The published records of Lorentz (1867), Geheeb (1902), Hart (1891), Rabinowitz-Sereni (1931), Bizot (1945) and Proskauer (1953) concern Palestine only partially.

The following enumeration of Palestine mosses is based on the collections of the Herbarium of the Hebrew University mostly made by T. Kushnir and D. Zohary, as well as by the present authors. Species known to the authors only from the literature are not included.

The present list comprises 131 moss species and varieties, among them one new species and two new varieties. Fifty species, marked with an asterisk, are apparently new to the Eastern Mediterranean.

In a later paper the authors intend to add data from the above literature.

We consider this list important also from the ecological point of view, since it comprises a number of mosses occurring in desert and semi-desert areas hitherto not adequately investigated.

ABBREVIATIONS

A — Acre Plain
Ca — Carmel
CN — Central Negev
EN — Eastern Negev
EY — 'Emeq Yizreel
J — Judean Mountains
Le — Lebanon
LG — Lower Galilee
LJ — Lower Jordan Valley
S — Shomron
Sh — Sharon
She — Shefela
UG — Upper Galilee
UJ — Upper Jordan Valley
WN — Western Negev

(B) — F. Bilewsky
(EA) — A. Eig and I. Amdursky
(F) — N. Feinbrun
(Fr) — Y. Friedberg
(G) — A. Grizi
(Ga) — Galili
(J) — D. Jaffe
(K) — T. Kushnir
(Ka) — A. Kadman
(L) — N. Landau
(N) — S. Nachmony
(Ne) — M. Negbi
(O) — S. Osherov
(R) — D. Raz (Rizik)

(S) — D. Rabinovitz-Sereni
(W) — M. Warburg
(We) — Y. Weisel
(Z) — M. Zohary
(ZD) — D. Zohary

c. fr. — cum fructificatione (where no mention of capsules is made, the specimens are sterile)

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SYSTEMATIC LIST

DICRANALES

* *Ditrichum subulatum* Bruch-Hampe

Sh: Env. of Heftsi-Bah, 200 m, IX. 1943 (K); UJ: Susita, 250 m, III. 1944 (K).

* *Pleuridium alternifolium* (Dicks.) Rabh.

J: Beit Jimal, 400 m, on rocks, III. 1954 (B); Ca: Wadi Tira, 350 m, III. 1952 (B).

* *Pleuridium subulatum* (Huds.) Rabh., c. fr.

Sh: Wadi Faliq, 100 m, on soil, III. 1953 (B); S: Env. of Pardess Hanna, 200 m, III. 1943 (K).

Ceratodon purpureus (L.) Brid., c. fr.

UG: Wadi Qarn, 400 m, on rocks, IV. 1954 (B).

Anisothecium rubrum (Huds.) Lindb., c. fr.

Sh: Env. of Yarqon, 30 m, III. 1954 (N), env. of Herzliya, 100 m, II. 1943 (R), III. 1954 (N), Wadi Faliq, 100 m, III. 1954 (N); J: Env. of Jerusalem, 800 m, II. 1943 (K); S: Wadi Abu Lidja, II, 1943 (K); Ca: Wadi Falah, 300 m, III. 1954 (N), Wadi Shumriyeh, III. 1943 (K); EY: Wadi Zara'iin. VI. 1943 (K), env. of Giv'at Hamore, 500 m, III. 1954 (N), Alonim, III. 1954 (N); UG: Env. of Safad, 700 m, IV. 1954 (G); UJ: Wadi Jalud, III. 1945 (K), wadi near 'Ein Gev, 100 m, II. 1943 (K). Le: Baniass, IV. 1945 (K), Hasbani Bridge near Sucher-Chen, IX. 1943 (K).

FISSIDENTALES

* *Fissidens minutulus* Sull.

CN: Makhtesh Ramon, 200 — 400 m, on rocks, II. 1954 (Ne).

Fissidens mnevidis Amann, c. fr.

Sh: Env. of Tantura, 50 m, on dry rocky ground, III. 1954 (B); UG: Wadi Qarn, on stones partly submerged in water, VI. 1954 (B), Tel el Qadi, 200 m, IV. 1954 (B).

Fissidens warnstorfii Fleisch., c. fr.

Sh: Wadi Faliq, 100 m, on soil, III. 1954 (B); J: Sha'ar Hagai, 500 m, on dry woodland, V. 1954 (B); LG: Kfar Hahoresh, 350 m, II. 1944 (K); UG: Wadi Qarn, on moist ground, IV. 1953 (B), Tel el Qadi, IX. 1942 (K).

POTTIALES

Encalypta vulgaris (Hedw.) Hoff., c. fr.

J: Env. of Jerusalem, 800 m, XII. 1942, I. 1943 (K), env. of Motza, 700 m (L), env. of Hebron, 650 m, I. 1944 (K); UG: Jarmaq, 1200 m, on calcareous rocks, IV. 1952, IV. 1954 (B); UJ: Susita, 250 m, on rocks, III. 1944 (K). Le: 'Ainata, X. 1943 (K).

Timmiella barbuloides (Schw.) Limpr., c. fr.

Occurs on various substrates, common throughout.

Eucladium verticillatum (L.) Br. eur., c. fr.

She: Ben Shemen, 150 m, I. 1955 (B); J: Jerusalem, 700 m, I. 1943 (ZD), env. of Dir 'Amar, 750 m, V. 1943 (K); S: Kabarah cave, 100 m, VIII. 1943 (A. Borut); UG: Wadi Qarn, IV. 1954 (B), on wet stones of aqueduct near Kabrita, 50 m, II. 1953 (B), Wadi Karkarah, 300 m, II. 1953 (B); LJ: 'Ein Gedi, 300 m below sea level, V. 1953 (B).

Tortella flavovirens (Bruch) Broth.

Sh: Wadi Faliq, 100 m, on limestone rocks, X. 1953 (B); A: Env. of Nahariya, 50 m, III. 1953 (B); UG: Jarmaq, 1000 m, IV. 1952 (B).

Tortella humilis (Hedw.) Jennings, c. fr.

Ca: Wadi Tel Hanan, 300 m, no date (Ga).

Tortella nitida (Lindb.) Broth., c. fr.

She: Ben Shemen, I. 1955 (B); Sh: Env. of Tantura, 50 m, on rocks, IV. 1954 (B); UG: Safad, 700 m, IV. 1953 (B), Wadi Qarn, IV. 1954 (B), Wadi Karkarah, III. 1953 (B).

Leptobarbula berica (De Not.) Schpr., c. fr.

UG: Env. of Nazareth, III. 1944 (K). Le: Env. of Baniass, IV. 1954 (K).

Trichostomum brachydontium Bruch

Ca: Wadi Tel Hannan, ca. 300 m, no date (Ga); UG: Teteba, above Kafr Mande, ca. 500 m, on calcareous rocks, IV. 1954 (B).

* *Trichostomum triumphans* De Not. var. *pallidisetum* Husnot, c. fr.

Sh: Env. of Ramat Gan, on soil, ca. 100 m, III. 1952 (B).

* *Trichostomum cylindricum* (Bruch) C. Muell., c. fr.

UG: Heidar, ca. 1000 m, on calcareous rocks, IV. 1952 (B). Le: Fureides, X. 1943 (K).

* *Weisia curvirostris* Ehr.

She: Nitsanim, ca. 150 m, IV. 1952 (B); Sh: Yarqon bank, ca. 30 m, II. 1952 (B); J: Jerusalem, ca. 800 m, IV. 1952 (B), Sha'ar Hagai, ca. 500 m, IX. 1952 (B).

* *Weisia crispata* (Br. germ.) C. Muell., c. fr.

Le: Shibah, X. 1943 (K).

Hydrogonium ehrenbergii (Lor.) Jaeg. et Sauerb.

Sh: Yarkon bank, ca. 50 m, partly submerged in water, VIII. 1952 (B); J: Sha'ar Hagai, ca. 500 m, dry rocky woodland, X. 1953 (B); UG: Wadi Qarn, IV. 1954 (B), VII. 1954 (N), Wadi Karkarah, III. 1953 (B), VI. 1954 (W); LJ: 'Ein Gedi, V. 1954 (B); UJ: Hula, in a pool, VII. 1954 (N), Mukheiba, VII. 1943 (K); Le: Env. of Shibah, X. 1943 (K).

* *Barbula gracilis* (Schl.) Schw., c. fr.

Sh: Wadi Faliq, on calcareous rocks, X. 1953 (B); J: Beit Jimal on calcareous rocks, III. 1953 (B), env. of Jerusalem, I. 1954 (Ka); S: Maquis between Shfeiya and Bat Shlomo, IV. 1954 (G); Ca: IV. 1954 (B); EY: Alonim, III. 1954 (N); LG: Env. of Yavneel, III. 1954 (N), env. of Tavor, III. 1954 (N), env. of Giv'at Hamore, III. 1954 (N); UJ: Wadi Hindaj, ca. 400 m, on rocks, IV. 1954 (B), env. of Beit Yerah, III. 1954 (F).

Barbula fallax Hedw., c. fr.

Occurs on various substrates, common throughout.

* *Barbula revoluta* (Schr.) Brid., c. fr.

Sh: Wadi Faliq, II. 1954 (B); J: Beit Jimal, IV. 1954 (B); Ca: Wadi Tel Hannan (Ga); UG: Jarmaq, IV. 1954 (B). All on calcareous rocks.

* *Barbula rigidula* (Hedw.) Mitt.

LJ: Wadi Nahr, IX. 1943 (K), env. of Jericho, 200 m b.s.l., II. 1943 (K). Both samples show very short apices.

Barbula unguiculata Hedw., c. fr.

Sh: Env. of Ramat Gan, V. 1952 (B), near Yarqon bridge on Tel-Aviv — Herzliya road, III. 1954 (N); J: Deir es Sheikh, II. 1943 (K); S: Abu Lidja, II. 1943 (K); Ca: III. 1953 (B); EY: Alonim, III. 1954 (N), 'Ein Harod, III. 1927 (L); LG: Wadi Biriya, in basalt canyon, VIII. 1943 (K); UJ: Env. of 'Ein Gev, III. 1944 (K); LJ: Env. of Jericho, III. 1943 (K); Le: Baniass, IV. 1945 (K), Hasbani Bridge near Sucher-Chen, X. 1943 (K). All either on rocks or on dry soil.

* *Barbula convoluta* Hedw., c. fr.

UG: Env. of Meiron, IV. 1954 (G); Le: Shibah, X. 1943 (K).

* *Barbula commutata* Jur., c. fr.

Le: Fureides, X. 1943 (K).

Barbula vinealis Brid., c. fr.

Sh: Env. of Tel Aviv and Ramat Gan, X. 1952, II. 1953 (B); J: Env. of Jerusalem, X. 1952 (B), Deir es Sheikh, II. 1943 (K), Deir Yassin, I. 1943 (K); S: Chan Lubban, III. 1945 (K), no locality, V. 1945 (K); UG: Env. of Safad, IV. 1953 (We), Wadi Qarn, IV. 1954 (B); UJ: Env. of old Hatsor (antiquities), III. 1953 (B). All either on rocks or on dry soil.

* *Barbula vinealis* Brid., var. *cylindrica* (Tayl.) Boul., c. fr.

S: Maquis between Shfeiya and Bat Shlomo, IV. 1954 (G); LG: Env. of Beit Qeshet, III. 1954 (N).

Didymodon luridus Hornsch., c. fr.

J: 'Ein Kerem, II. 1954 (N), Aqua Bella, II. 1954 (N); UG: Jarmaq, IV. 1954 (B), Wadi Qarn, VI. 1954 (B); UJ: Wadi Hindaj, IV. 1954 (B). All on calcareous rocks.

Didymodon tophaceus (Brid.) Mitt., c. fr.

A: Env. of Nahariya, III. 1953 (B); J: Sha'ar Hagai, X. 1952 (B); UG: Wadi Qarn, no date (K), VII. 1943 (R); LJ: Wadi Qilt, no date (K); UJ: Env. of 'Ein Gev, II. 1944 (K). All on soil.

Gymnostomum calcareum Br. eur., c. fr.

Sh: Ramat Gan, I. 1943 (K), Kfar Shmaryahu, 50 m, X. 1953 (B), Yarqon bank, III. 1953 (B); A: Bahay house near Acre, IV. 1952 (B); WN: Kvish Merhavim, III. 1954 (N); CN: Makhtesh Ramon, II. 1953 (Ne); J: Env. of Jerusalem, I. 1940, XII. 1940 (K), I, III, XII. 1941 (K, ZD), I. 1942 (ZD), II. 1943 (ZD), II. 1954 (N), Deir es Sheikh, III. 1941 (K), II. 1943 (ZD, K), on the Jerusalem—Katrah road, III. 1954 (N), 'Ein Kerem, II. 1954 (N); S: Shfeiya, IV. 1937 (L), maquis between Shfeiya and Bat Shlomo, IV. 1954 (G); Ca: Env. of Isfiya, III. 1954 (B), Wadi Falah, III. 1954 (Z, N), Wadi Shumriyeh, II. 1941, III. 1943 (K), Haifa, Hadar Hacarmel, IV. 1937 (L); EY: Alonim, III. 1954 (N); Gilbo'a, IV. 1927 (S), IV. no year, I. 1945 (K); LG: Sheikh Abreiq, IV. 1937 (L), Balfour Forest, in the mouth of a cave, IV. 1937 (L), Kfar Hahoresh, ca. 350 m, III. 1944 (K), env. of Nazareth, III. 1954 (N), wadi above Yavneel, basalt soil, IX. 1943 (K), env. of Beit Qeshet, III. 1954 (N); UG: Yehi'am, III. 1954 (W), Jarmaq, X. 1954 (We); UJ: Wadi Hindaj, basalt, IV. 1954 (We), Wadi Jalud, near Sde Nahum, III. 1945 (K); 'Emeq Beit Shean, rocks in the Sachne, X. 1943 (K). Mostly from calcareous stones or ground.

Gyroweisia mosis (Lor.) Par., c. fr.

EY: Giv'at Hamore, III. 1944 (K). First collected by Ehrenberg from Mount Serbal, Sinai, described by Lorentz from sterile specimen. Our sample, with sporogon, resembles *G. acutifolia* Phil., but, according to Prof. Bizot, it is more probable that it represents a fructified *G. mosis*. This interesting specimen will be examined further.

Hymenostomum tortile Br. eur. = *Wiesia tortilis* (Schw.) C. Muell., c. fr.

Sh: Env. of Herzliya, II. 1943 (K), garigue at km. 100 on the Tel Aviv — Haifa road, III. 1954 (N); J: Env. of Jerusalem, XII. 1940 (K), I. 1941 (ZD), I. 1942 (ZD), I, III. 1943 (ZD, K), IV. 1952 (B); S: Pardess Hanna, III. 1943 (K); EY: Env. of 'Ein Harod, I. 1941 (K); Le: Env. of Shibah, X. 1943 (K). All on soil.

* *Astomum crispum* (Hedw.) Hampe, c. fr.

S: Env. of Pardess Hanna, III. 1943 (K); J: Sha'ar Hagai, X. 1952 (B). All on soil.

Tortula muralis (L.) Hedw., c. fr.

Occurs on various substrates, common throughout.

* *Tortula canescens* (Bruch) Mont.

LJ: Wadi Qilt, near Jericho, probably on rocks, no date (K), together with *Bryum erythrocarpum* and *Didymodon tophaceus*.

Tortula marginata (Br. eur) Spruce, c. fr.

Sh: Tel-Aviv, on the roots of *Phoenix* sp. V. 1952 (B), Wadi Faliq, III. 1954 (N); A: Env. of Nahariya on soil, III. 1952 (B); J: Sha'ar Hagai, X. 1952 (B), Battir, II. 1943 (K); Ca: III. 1953 (B), III. 1954 (N); LG: Sheikh Abreiq, IV. 1937, Dabburiya, III. 1954 (N).

Tortula atrovirens (Sm.) Lindb., c. fr.

She: Env. of Lydda, ca. 100 m, no date (K); J: Env. of Jerusalem, II. 1943 (D), Sheikh Bader, III. 1952 (B); LG: Giv'at Hamore, XII. 1941 (K), together with *Crossidium squamigerum*; LJ: Env. of Jericho, III. 1943 (K). All either on soil or on rocks.

* *Tortula wahliana* (Schultz) De Not.

She: Env. of Ashqelon, III. 1954 (J); LJ: Env. of Jericho, III. 1943 (K); UJ: Env. of 'Ein Gev, X. 1943 (K). All on rocks.

* *Tortula guepini* Schpr., c. fr.

UJ: Susita, on rocks, ca. 250 m, III. 1944 (K).

Tortula cuneifolia (Dicks.) Roth, c. fr.

Sh: Env. of Herzliya, II. 1943 (K), Kfar Yedidya, 100 m, II. 1954 (B); S: Pardess Hanna, III. 1943 (K, O); J: Gat Samna, VII. 1943 (K); UJ: Wadi 'Ein Gev, III. 1944 (K).

Tortula **israelis** Bizot et Bilewsky, species nova.

T. murali affinis, a qua differt statura minore. Folia minuta, plana vel minus revoluta, 0.7—1 mm. Cellula papillam unicam cavam cylindroconicam fert, apice dilatata. Nec irregulariter ramosa, sterilis.

This new very small plantlet is a form parallel to *T. papillosissima* (Cop.) Broth. and near to *T. muralis;* it differs from the latter by the length of its leaves reaching at the most 1 mm, and by the shape of the cells, each bearing one cylindroconical papilla. The apex of the leaf is lanceolate and the smooth hyaline hair is sometimes twice as long as the leaf.

J: Sha'ar Hagai, IV. 1954 (B), Beit Jimal, V. 1954 (B). Both on rocks and stones.

* *Tortula brevissima* Schiffn., c. fr.

On soil, near the Jordan, without further location, IV. 1943 (K).

Tortula subulata (L.) Hedw., c. fr.

J: Env. of Battir, III. 1943 (K); EY: Env. of Harod spring, III. 1944 (K). Both on rocks.

Tortula inermis (Brid.) Mont., c. fr.

J: Env. of Jerusalem, XII. 1941 (K), XII. 1942 (K), I. 1943 (K), III. 1952 (B), III, IV. 1954 (N), env. of Hebron, I. 1944 (K), Qiryat 'Anavim, II. 1953 (Z), Wadi Riaz, I. 1952 (F); UG: Jarmaq, IV. 1954 (B), env. of Meiron, IV. 1954 (G); Le: Env. of Shibah, X. 1943 (K). All on calcareous rocks.

Tortula ruralis (L.) Ehrh., c. fr.

J: Env. of Hebron, I. 1943 (K); Le: Env. of Shibah, X. 1943 (K). Both on rocks.

Tortula montana (Nees) Lindb., c. fr.

J: Env. of Jerusalem, on rocks, X. 1952 (B); UG: Jarmaq, IV. 1952 (B), spring near Ka'ba'a — Kna'an, IV. 1954 (B), env. of Ramim, XI. 1943 (K); Le: Env. of Shibah, X. 1943 (K). All on calcareous rocks.

* *Tortula norvegica* (Web.) Wahlenb., c. fr.

J: Env. of Hebron, II. 1941 (Z).

Pottia commutata Limpr., c. fr.

Sh: Ramat Gan, no date (K); J: Jerusalem, I, II. 1943 (ZD); LG: Balfour Forest, IV. 1937 (L); Le: Baniass, IV. 1945 (K). All on soil.

* *Pottia minutula* Br. eur., c. fr.

J: Env. of Jerusalem, no date (K); S: Pardess Hanna, III. 1943 (K); Ca: Wadi Tira, III. 1953 (B); LG: Env. of Nazareth, II. 1944 (K); LJ: Wadi Qilt, III. 1943 (K); UJ: Env. of Sde Nahum, III. 1943 (K). All on soil.

* *Pottia minutula* Br. eur. var. *conica* Schl., c. fr.

J: Env. of Jerusalem, on soil, III. 1943 (K).

Pottia venusta Jur., c. fr.

UJ: Env. of Sde Nahum, on earth III. 1945 (K).

Pottia starkeana (Hedw.) C. Muell., c. fr.

Sh: Ramat Gan, II. 1953 (B); EN: without further location, III. 1954 (N); J: Jerusalem, I. 1943 (ZD), Battir, II. 1943 (K); Ca: III. 1954 (N); LJ: Jericho, Wadi Qilt, III. 1943 (K); UJ: Wadi Hindaj, IV. 1954 (B). All on soil.

Pottia mutica Vent., c. fr.

Sh: Natanya, III. 1954 (N), env. of Kfar Hayim, III. 1954 (N); J: Env. of Jerusalem, I. 1942 (K), I, II. 1943 (ZD, K), II, III. 1954 (N), Aqua Bella, II. 1954 (N), Wadi Sarar, III. 1954 (N); Ca: III. 1954 (N); UJ: 'Ein Gev, no date (K). All on soil.

* *Pottia mutica* Vent. var. *gymnostoma* Corb, c. fr.

J: Jerusalem, I, II. 1943 (ZD, K); S: Pardess Hanna, III. 1943 (K). All on soil.

Crossidium squamigerum Jur., c. fr.

She: Lydda, ca. 150 m, no date (B); Sh: Ramat Gan, I. 1943 (K), VIII. 1953 (B), Herzliya Cave, I. 1954 (Ka); CN: 'Avdat, ca. 350 m, III. 1953 (B), Nahal Ramon, I. 1954 (Ne); J: Env. of Jerusalem, XII. 1942 (K), III. 1943 (K), II. 1954 (N), VII. 1952 (B), 'Ein Kerem, III. 1954 (N), Motza, I. 1954 (N), Katra, III. 1954 (N); Ca: Isfiya, ca. 500 m, III. 1954 (B); LG: Giv'at Hamore, no date (K); UG: Jarmaq, IV. 1952 (B), Har Kena'an, III. 1952 (B), Montfort, IV. 1954 (B); LJ: Jericho, III, V. 1943 (K). All on rocks.

* *Crossidium chloronotus* (Brid.) Limpr.

EN: Env. of Kurnub, ca. 350 m, on rocks, I. 1944 (K).

* *Crossidium laevipilum* Thériot et Trabut

LJ: Env. of Jericho, on soil, III. 1943 (K).

Aloina aloides Kindb., c. fr.

J: Jerusalem, I. 1941, XII. 1942 (K); S: Maquis between Shfeiya and Bat Shlomo, IV. 1954 (G); LG: Env. of Kfar Hahoresh, II. 1944 (K); Le: Env. of Shibah, X. 1943 (K). All on soil.

Aloina ambigua (B. et S.) Limpr., c. fr.

She: Ness Ziona, I. 1942 (K), Nahalat Yehuda, I. 1954 (N); Sh: Ramat Gan, II. 1952 (Fr), Yarqon bank, X. 1953 (B), env. of Herzliya, I. 1954 (Ka); EN: Wadi Sekher, III. 1954 (N); J: Jerusalem, I, II. 1943 (K), X. 1952 (B), 'Ein Kerem, II. 1954 (N), Aqua Bella, II. 1954 (N), Beit Jimal, IV. 1954 (B); Ca: Wadi Shumriyeh, II. 1944 (K), road to Beit Oren, III. 1954 (N); LG: Env. of Nazareth, III. 1944 (K); UG: Wadi Karkara, III. 1953 (B); LJ: Jericho, III. 1943 (K); Le: Baniass, IV. 1945 (K).

Aloina stellata (Schreb.) Kindb., c. fr.

Sh: Env. of Tantura, IV. 1954 (B); LG: Balfour Forest, IV. 1937 (L). Both on soil.

* *Aloina stellata* (Schreb.) Kindb. var. *pilifera* (Schpr.) Limpr., c. fr.

EN: Wadi Sekher, III. 1954 (N), Wadi Migra, III. 1954 (N); LJ: Between Jerusalem and Jericho, III. 1943 (K). Both on soil.

Pterygoneurum cavifolium Jur., c. fr.

J: Jerusalem, I, II, III. 1942, I, II, III. 1943 (K, ZD), II. 1952 (B), I, II. 1954 (N). All on rocks.

* *Phascum curvicollum* Hedw., c. fr.

J: Jerusalem, III. 1943 (K).

* *Phascum cuspidatum* Schreb. var. *piliferum* H. et T., c. fr.

Sh: Env. of Ramat Gan, II. 1943 (K), env. of Natanya, III. 1954 (N); J: Jerusalem, I. II, III. 1943 (ZD, K), Beit Jimal, IV. 1954 (B); S: Pardess Hanna, III. 1943 (K); LG: Env. of Nazareth, II. 1944 (K); UG: Env. of Hunein, IV. 1952 (B), Wadi Qarn, IV. 1954 (B); UJ: Susita, III. 1944 (K). All on soil.

* *Acaulon muticum* (Schl.) C. Muell. var. *cuspidatum* Schpr., c. fr.

J: Jerusalem, III. 1943 (ZD); S: Pardess Hanna, III. 1943 (K).

GRIMMIALES

* *Grimmia apocarpa* Hedw. var. *atrofusca* Husnot

Le: Env. of Shibah, X. 1943 (K), together with *G. pulvinata* and *Orthotrichum subulatum.*

* *Grimmia crinita* Brid.

CN: 'Avdat, IV. 1953 (B), IV. 1954 (W); UG: Jarmaq, IV. 1952 (B), Ramim, ca. 750 m, IV. 1952 (B). All on rocks.

Grimmia pulvinata Smith, c. fr.

J: Jerusalem, XII. 1940 (K, ZD), II, XII. 1941 (K), I, III. 1943 (ZD, K), I, III. 1954 (N), Wadi Deir Yassin, I. 1943 (K), Aqua Bella, II. 1954 (N), env. of Hebron, II. 1941 (Z); UG: Jarmaq, IV. 1954 (B), env. of Hurfeish, ca. 600 m, IV. 1954 (B), Safad, IV. 1953 (B), Heidar, IV. 1952 (B); UJ: Dardara, I. 1943 (K), Lehavot Habashan, IV. 1954 (B). All on rocks.

* *Grimmia trichophylla* Greve var. *meridionalis* Schpr., c. fr.

Le: Baniass, on rocks, IV. 1945 (K).

Grimmia campestris Bruch, c. fr.

UJ: Env. of Dardara, I. 1943 (K), Qarnei Hittin, X. 1942 (K). Both on basalt rocks.

FUNARIALES

Ephemerum minutissimum Lind., c. fr.

S: Pardess Hanna, on earth, III. 1943 (K).

Ephemerum sessile (Bruch et Schpr.) C. Muell. var. **kushniri** Bizot, var. nova.

Capsula minor, sporae majores, 90 — 100 μ (non ut in typo 50 — 80 μ).
Capsule smaller, spores 90 — 100 μ (not as in type 50 — 80 μ).

S: Env. of Pardess Hanna, on soil, III. 1943 (K).

* *Ephemerum recurvifolium* (Dicks.) Boul.

Sh: Env. of Heftsi-Bah, on soil, II. 1944 (K).

Funaria (*Enthostodon*) *durieui* (Mont.) Broth. var. *mustaphae* (Trab.) Bizot, c. fr.

UG: Wadi Qarn, on dry rocks not far from the spring, VI, 1954 (B).

* *Funaria pallescens* (Jur.) Broth., c. fr.

UG: Jarmaq, on calcareous rocks, IV. 1952 (B).

Funaria dentata Crome, c. fr.

Sh: Sheva' Tahanot, Yarkon bank, on an old wall, V. 1953 (B), together with *Tortula muralis* and *Timmiella barbula.*

Funaria mediterranea Lindb., c. fr. = *F. neglecta* De Not.

J: Jerusalem, no date (N), Beit Jimal, III. 1954 (B), Battir, III. 1943 (K); EY: Harod Spring, on earth, III. 1945 (K); UJ: Wadi Hindaj, IV. 1954 (B), env. of 'Ein Gev, III. 1944 (K).

Funaria curviseta Milde, c. fr.

UG: Wadi Karkara, III. 1942 (K); UJ: 'Emeq Beit Shean, IX. 1943 (K), Wadi Hammam, I. 1945 (K).

Funaria convexa Spruce, c. fr.

Ca: Env. of Isfiya, on road stones, III. 1954 (B).

Funaria hygrometrica (L.) Sibth., c. fr.

Occurs on various substrates, common throughout.

EUBRYALES

* *Webera calcarea* Warnst., c. fr.

Sh: Yarqon bank, on earth, II. 1952 (B).

Mniobryum carneum (L.) Limpr., c. fr.

UG: Wadi Karkara, on rocks, 300 m, III. 1953 (B).

Bryum pallescens Schleich., c. fr.

Sh: Env. of Ra'anana, ca. 150 m, III. 1954 (B), Wadi Faliq, X. 1953 (B); Ca: Wadi Shumriyeh, no date (K); UG: Jarmaq, Har Kena'an, env. of Eilon, IV. 1952 (B). All on calcareous rocks.

* *Bryum caespiticium* L., c. fr.

Sh: Wadi Faliq, II. 1954 (B); J: Beit Jimal, III. 1954 (B); LJ: Wadi Far'a, no date (K); UJ: Old Hatsor, III. 1954 (B). All either on rocks or on soil.

* *Bryum caespiticium* L. var. *kuntzei* (Hornsch.) Warnst.

She: Ruins of Ashqelon, on old stones, ca. 30 — 50 m, VI. 1953 (B).

Bryum argenteum L.

J: Jerusalem, III. 1943 (K), env. of 'Azaria, III. 1943 (K); UG: Jarmaq, IV. 1952 (B); UJ: Hagoshrim, ca. 100 m, IV. 1952 (B). All on soil.

Bryum murale Wils., c. fr.

Ca: Haifa, lower town, on an old wall, III. 1954 (B).

Bryum erythrocarpum Schw.

UG: Env. of Melaha, 350 m, III. 1954 (B); LJ: Wadi Qilt, no date (K); Le: Baniass, IV. 1945 (K) All on rocks.

Bryum bicolor Dicks., c. fr.

She: Yad Mordekhai, X. 1953 (B), Ben Shemen, ca. 250 m, I. 1955 (B); Sh: Herzliya, no date (K), Wadi Faliq, X. 1953 (B); J: Env. of Jerusalem, X. 1953 (B), Sha'ar Hagai, IV. 1954 (B), Beit Jimal, III. 1954 (B); Ca: Wadi Tira, III. 1953 (B); UG: Har Kena'an, IV. 1954 (B). Both on rocks and on soil.

Bryum torquescens Br. eur.,

Sh: Env. of Tantura, on soil, III. 1954 (B); J: Beit Jimal, on rocks, III. 1954 (B).

Bryum capillare L., c. fr.

J: Jerusalem and Sha'ar Hagai, X. 1952 (B); Ca: Wadi Tel Hannan, no date (Ga), env. of Beit Oren, III. 1953 (B); UG: Jarmaq and env. of Ramim, IV. 1952 (B). All on rocks.

Bryum donianum Grev.

UG: Env. of Hunein, basalt, IV. 1945 (K).

* *Bryum splachnoides* (Harv.) C. Muell., c. fr.

LJ: Env. of 'Ein Gedi, 300 m b.s.l., on rock near the spring, V. 1953 (B).

* *Mnium seligeri* (Jur. et Milde) Lindb.

Le: 'Einot Shibah, on wet meadow, X. 1943 (K).

* *Philonotis marchica* (Willd.) Brid. var. *rivularis* Warnst.

LJ: Nahal David, 'Ein Gedi, V. 1953 (B).

Philonotis laxissima (C. Muell.) Br. eur.

Le: Baniass, X. 1942 (K); Hasbani Bridge, near Sucher-Chen, X. 1943 (K). Attached to the rocks in running water, submerged.

Philonotis laxissima (C. Muell.) Br. eur. var. **gemmiclada** Bizot var. nova.

A typo differt: numerosis axillaribus, facile caducis ramusculis, propagulorum locum tenentibus.

Differs from type by numerous axillar, easily deciduous branchlets, which fulfill the function of propaguli.

Le: Baniass, X. 1943 (K).

Orthotrichum tenellum Bruch

Le: Fureides, X. 1943 (K), together with *Grimmia pulvinata.*

ISOBRYALES

Leucodon sciuroides Schw., c. fr.

LG: Hittim, on basalt rocks, 1942 (K), Mt. Tavor, on *Quercus calliprinos*, III. 1954 (N); UG: Jarmaq, Heidar and Ramim, on rocks, IV. 1952 (B), env. of Meiron, on *Olea europaea*, IV. 1952 (B), together with *Leptodon smithii.*

* *Leucodon sciuroides* Schw. var. *morensis* De Not.

LG: Env. of Hittim, on basalt rocks, 1942 (K). The sample approaches the norm closely but requires further examination.

Neckera complanata (L.) Hüb., c. fr.

Ca: Wadi Shumriyeh, IV. 1944. (K); UG: Wadi Qarn, III. 1942 (K).

Pterogonium gracile Sw. = *P. ornithopodioides* (Huds.) Lindb.

UG: Env. of Ramim, IV. 1952 (B), env. of Peqi'in, on basalt rocks, no date (K), together with *Leptodon smithii.*

Scorpiurium circinatum (Brid.) Fleisch. et Loeske, c. fr.

Sh: Hadera, III. 1943 (O), Tantura, on wet stones in the brook, IV. 1954 (B); S: Maquis between Shfeiya and Bat Shlomo, IV. 1953 (G); Ca: Wadi Tel Hannan, on rocks, no date (Ga), env. of Muhraqa, IV. 1954 (B), Isfiya and Wadi Shumriyeh, IV. 1954 (B), Wadi Falah, III. 1954 (N), Nahal Hanehashim, II. 1941 (K), Horshat Haarba'im, III. 1954 (N); LG: Har Tavor, II. 1943 (K), III. 1954 (N), Teteba, env. of Kafr Manda, on *Quercus calliprinos*, IV. 1954 (B); UG: Wadi Qarn, on *Quercus calliprinos* and *Platanus orientalis* and on stones, together with *Tortella* sp., IV. 1954 (B), Wadi Karkara, VI. 1940 (K), Yehi'am, III. 1954 (W), Wadi Biriya, VII. 1943 (K); UJ: Wadi Hindaj, IV. 1954 (B), Tel el Qadi, XI. 1943 (K), IV. 1954 (B).

Scorpiurium deflexifolium (Sch.) Fleisch. et Loeske

Ca: Wadi Falah, III. 1954 (N); Le: Fureides, X. 1943 (K), Hasbani Bridge near Sucher-Chen, X. 1943 (K).

Leptodon smithii Mohr.

UG: Wadi Qarn, IV. 1954 (Ka), env. of Peqi'in, on basalt, together with *Pterogonium gracile*, no date (K), Jarmaq, IV. 1952 (B), Meiron, on *Olea europea*, together with *Leucodon sciuroides* IV. 1952 (B); UJ: Tel el Qadi, XI. 1943 (K).

HYPNOBRYALES

* *Fabronia pusilla* Raddi, c. fr.

J: Jerusalem, I. 1943 (K), Khirbet Qrin near Kfar 'Etsyon, on soil under stones, II. 1943 (K).

* *Fabronia octoblepharis* Schw., c. fr.

UG: Env. of Meiron, on *Olea europaea*, IV. 1952 (B).

Amblystegium serpens (L.) Br. eur.

UJ: Tel el Qadi, XI. 1943 (K).

* *Amblystegium varium* (Hedw.) Lindb.

Le: Hermon, on rocks, X. 1943 (K). Slightly different from the type, a slender form.

* *Amblystegium juratzkanum* Schpr.

Le: Env. of Hasbani Bridge near Sucher-Chen, X. 1943 (K).

* *Camptothecium lutescens* (Lag.) Br. eur.

UG: Env. of Hunein, on rocks, IV. 1954 (B), together with *Bryum donianum*.

Camptothecium aureum (Lag.) Br. eur., c. fr.

J: Jerusalem, I. 1941 (ZD), II. 1943 (K), I. 1954 (N), Motsa, XII. 1953 (N), env. of Beit Ommar, Hebron, I. 1933 (EA), env. of Hartuv, IV. 1926 (no collector); LG: Har Tavor, III. 1954 (N); UG: Meiron, IV. 1954 (G), Jarmaq, X. 1954 (We), Wadi Qarn, IV. 1954 (Ka), env. of Hunein, 1943 (K).

Homalothecium sericeum (L.) Br. eur., c. fr.

J: Jerusalem, II. 1925 (D), Sicha near Deir es Sheikh, III. 1937 (L), env. of Beit Ommar on the Jerusalem — Hebron road, I. 1933 (EA).

Homalothecium sericeum (L.) Br. eur. var. *robustum* Warnst.

UG: Env. of Meiron, IV. 1954 (G).

* *Brachythecium populeum* (Hedw.) Br. eur., c. fr.

Le: Hermon, on rocks, X. 1943 (K).

Brachythecium velutinum (L.) Br. eur., c. fr.

Le: Env. of Shibah, X. 1943 (K).

Brachythecium velutinum (L.) Br. eur. var. *venustum* De Not.

Le: Env. of Fureides, X. 1943 (K).

Eurhynchium swartzii (Turn.) Carnow, c. fr.

Ca: II. 1941 (*I. Zamir*); UG: Env. of Hunein, IV. 1945 (K); Le: no further location, IX. 1942 (K).

Eurhynchium speciosum (Brid.) Milde, c. fr.

UJ: Tel el Qadi, IV, X. 1942, XI. 1943 (K).

* *Eurhynchium rusciforme* Milde var. *alopecuroides* Brid., c. fr. = *Platyhypnidium rusciforme* (Necker) Fleisch.

UJ: Tel el Qadi, IV. 1942 (K), IV. 1954 (B), partly submerged, attached to stones in running water, partly on *Quercus calliprinos*, together with *Rhynchostegiella curviseta*.

* *Rhynchostegium confertum* (Dicks.) B. et S.

J: Sha'ar Hagai, IV. 1954 (B); Ca: Wadi Tel Hannan, no date (Ga). Both on rocks.

Rhynchostegium megapolitanum (Bland.) Br. eur., c. fr.

J: Jerusalem, II. 1954 (N), Wadi Deir Yassin, I. 1943 (K), Aqua Bella, II. 1954 (N); Ca: Yagur, IV. 1937 (L); UG: Env. of Hunein, IV. 1945 (K). All on rocks.

Rhynchostegium megapolitanum (Bland.) Br. eur. var. *meridionale* Schr., c. fr.

J: Wadi Deir Yassin, II. 1943 (K).

Rhynchostegiella tenella Dicks. (=*R. algiriana* [Brid.] Broth.), c. fr.

J: Jerusalem, II. 1945 (ZD); Ca: II. 1941 (K), Haifa, III, 1954 (B); LG: Kfar Hahoresh, Ginneigar, II. 1944 (K); UG: Wadi Qarn, IV. 1954 (Ka), maquis near Hurfeish, I. 1945 (K), env. of Hunein, IV. 1945 (K). All on calcareous rocks.

Rhynchostegiella curviseta (Brid.) Limpr., c. fr.

J: Battir, II. 1943 (K); Ca: Wadi Falah, III. 1954 (N); UG: Wadi Qarn, on *Quercus calliprinos*, IV. 1954 (B), together with *Scorpiurium circinatum*, Har Kana'an, spring of Ka'ba'a, submerged in running water, IV. 1954 (B); UJ: Tel el Qadi, partly submerged, attached to stones in running water, IX. 1942 (K); Le: Baniass, VI. 1944 (K).

* *Rhynchostegiella curviseta* (Brid.) Limpr. var. *laevipila* Nicholson et Dixon ex Dixon, c. fr.

Ca: Wadi Tel Hannan, on rocks, no date (Ga).

* *Scleropodium purum* (L.) Limpr.

UG: Jarmaq, IV. 1952 (B).

Scleropodium illecebrum Br. eur., c. fr.

J: Env. of Motsa — Jerusalem, II. 1953 (B), Tsova, I. 1954 (N); UG: Jarmaq, III. 1950 (F); Le: Fureides, X. 1943 (K), Hasbani Bridge near Sucher-Chen, X. 1943 (K).

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ON *CLADOPHORA KERKENNAE* HAMEL AND *CL. ECHINUS* (BIAS.) KÜTZ.

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ABSTRACT

A detailed description of *Cl. kerkennae* is given; basal cell and rhizoids are described. The cell walls of *Cl. kerkennae* undergo changes after the death of the cell, and the appearance of the alga alters considerably. *Cl. echinus* shows similar *post mortem* changes; it possesses a basal cell and rhizoids which resemble those of *Cl. kerkennae*. Size of cells is the only distinctive character between these species.

Cladophora kerkennae was first described by Hamel in 1929 from material collected in Tunisia. It seems to be fairly common along the whole Mediterranean shore of Israel. The plants collected locally agree with Hamel's diagnosis and figure. However, in view of the incomplete data given by Hamel (e.g. he did not see rhizoids and basal cells), it seems worth while to present a more detailed description of this species.

Cl. kerkennae grows at a small depth on calcareous substrata of animal origin (*Serpula* etc.) which incrust sandstone rocks. It forms cushion-like, vivid green tufts, 2—3 cm across. The fronds are very rigid and grow rosette-like, decumbent to the substratum; they are richly branched, up to 30 mm long, interlaced by green rhizoids. Attachment to the substratum is by means of a basal cell. The upper and lower sections of the frond differ from one another in type of branching and in size and shape of their cells. The basal cell is turnip-shaped and branches in a root-like manner. In older fronds the basal cell is not always present. After its decay the fronds become attached to the substratum partly by means of rhizoids and partly by the filaments themselves penetrating between the particles of the substratum. In the *lower* section of the frond the filaments are profusely opposed-trichotomous, sometimes fourfold branched. Almost every cell bears branches. The cells are markedly clavate, and the base is frequently somewhat inflated. They are 170—270 (340) μ thick at the base and 250—350 (500) μ at the tip. Their length ranges between (570) 850—1200 μ. Ratio of length to width is 2.5—4.5. The *upper* section of the frond branches but little, the branchings being mostly irregularly unilateral. The cells (ramuli) are cylindrical, 170—230μ thick and 700—1500μ

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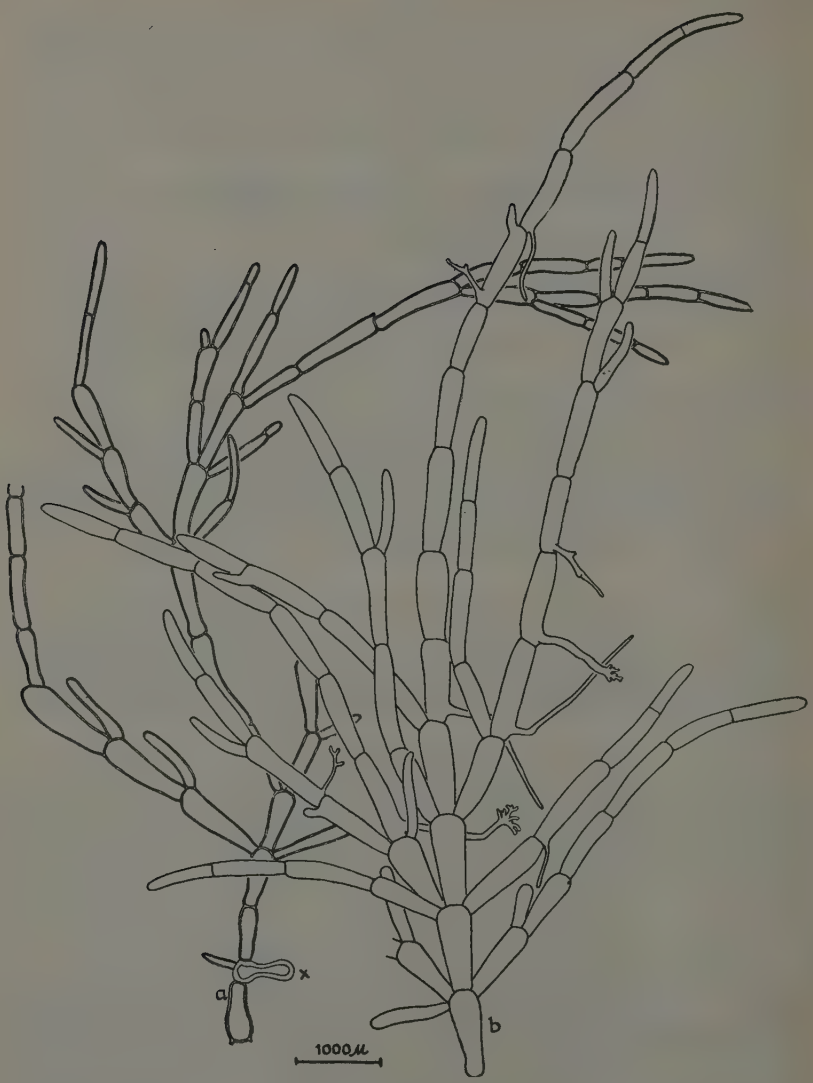

Figure 1

Cladophora kerkennae Hamel, fronds: *a*—all cells living except one (marked with *x*), thickness of cell walls shown; *b*—partly dead, thickness of cell walls not shown.

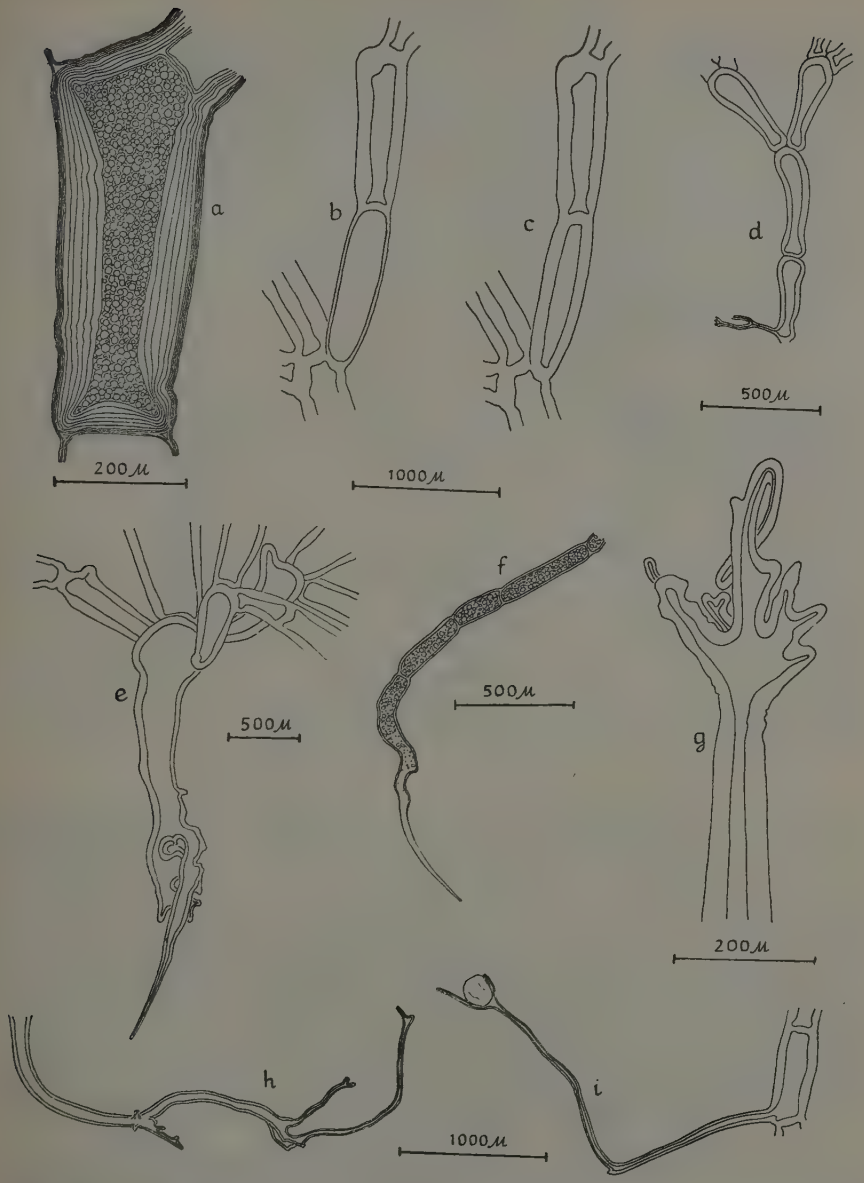

Figure 2

Cladophora kerkennae Hamel: *a*—swollen cell wall showing the inner and outer layer; *b*—two cells of a filament, the upper one dead, the lower one living; *c*—the same after drying and additional swelling in water, both cells dead; *d*—part of a filament with bone-shaped cells; *e, f*—basal cells; *g*—branched ending of a rhizoid; *h, i*—rhizoids, *i*—attaching itself to a substratum particle. All cells dead except *b*.

long. Ratio of length to width is 4—10. The basal part of these cells is sometimes slightly inflated. The rhizoids, not more than one to each cell, arise from the basal part of the cells. In some specimens the rhizoids are numerous, in others they are sparse. They are 20—125 (200) μ thick, tapering, up to 3000μ long, unbranched or branched, often knobby, growing in all directions. They contain chromatophores and do not possess cross walls. The rhizoids frequently branch apically in a finger-like fashion. As a rule, they attach themselves to other filaments or to the substratum (Figures 2 *g,h,i*). In the cushions there may occur smaller, poorly developed filaments. In one case the lower cells of such a filament were 85—115 μ thick at their base, 115—170 μ at their tip and 570—760 μ long (length: width = 3.8 — 4.5). The upper cells (ramuli) were 95—105 μ thick and 320—630 μ long (length: width = 3.5—6).

In the cell wall of *Cl. kerkennae* there occur several *post mortem* changes which are worthy of note. In dried specimens these may result in erroneous descriptions. The wall of the living cells is layered, 7—30 μ thick. After death it readily imbibes water and its thickness increases to 60 μ or more. At the same time, it turns glassy and the layers become more distinct. The cell wall in Figures 2 *b,c* was 20—25 μ thick in life as against 85 μ after drying and additional swelling in water. The cell wall swells *into* the lumen which thus decreases in size even though the shape of the cell may remain unchanged. In most cases the cell walls swell in a convex manner, thus causing the lumen to become more or less I-shaped. The longitudinal cell wall frequently collapses, the cell—externally—becoming bone-shaped (Figures 1 *a* at *x*, 2 *d*). These changes are apparently due to the inner layer of the cell wall swelling much more than the outer one (Figure 2*a*). The colour of the plant, too, changes after death. The vivid green of the chloroplasts darkens, while the swollen, glassy cell walls give the alga a greyish appearance. Hamel's description seems to refer to the dead plant, as he mentions a "greyish colour" and "very thick cell walls".

In connection with the observations on *Cl. kerkennae* it seemed of interest to examine the closely related species *Cl. echinus* (Bias.) Kütz. The diagnosis and figure given by Biasoletto are entirely uncharacteristic. However, the figure of Kützing (Tab. Phycol. IV. 62/1) shows swollen and distinctly layered cell walls and bone-like cell shapes very similar to those of dead cells of *Cl. kerkennae*. Living material from this species was not available but authentic herbarium specimens, collected by Biasoletto and distributed in Rabenhorst's 'Algen Sachsens', proved the correctness of Kützing's figure. It seems very probable that, after death, the cells of *Cl. echinus* suffer changes similar to those described for *Cl. kerkennae*. The examination of Biasoletto's material showed further that *Cl. echinus* possesses rhizoids and basal cells identical with those described for *Cl. kerkennae* (Figure 3 *a—c*). It should be pointed out that the figure of *Cl. echinus* from the Persian Gulf given by Boergesen differs from Biasoletto's material.

The above observations reveal the very close relationship between *Cl. kerkennae* and *Cl. echinus*. It appears that the only distinguishing character is the diameter of the cells. Different authors (Kützing, DeToni, Hauck and Boergesen) and the present author gave 50—150 μ for *Cl. echinus*, and Hamel gave 150—400 μ for *Cl. kerkennae*, while the plants found in Israel measured 170—500 μ. In this connection it should be pointed

out that the poorly developed filaments of *Cl. kerkennae* described above are 85—170 μ across, thus approaching *Cl. echinus*. However, the question of whether the preservation of *Cl. kerkennae* is justified requires further study.

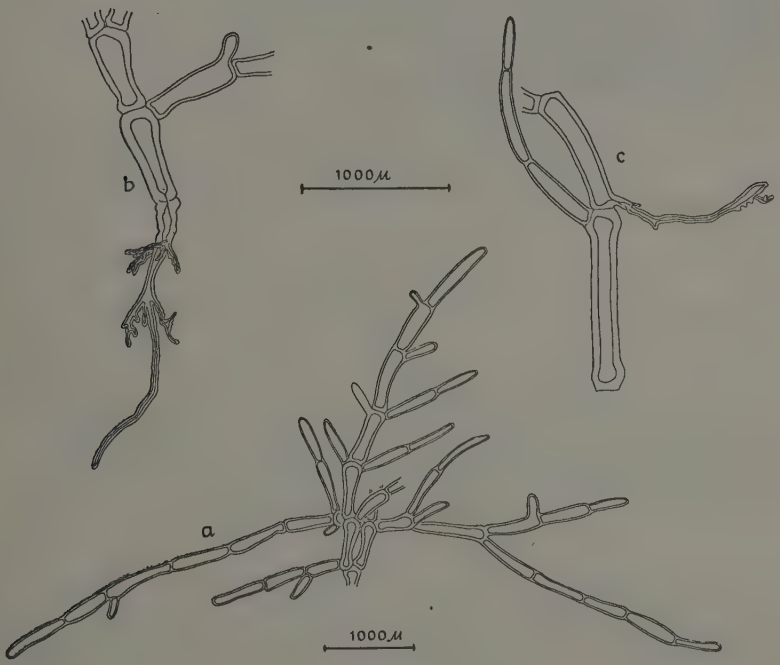

Figure 3

Cladophora echinus (Bias.) Kütz., authentic herbarium specimen of Biasoletto: *a*—frond; *b*—basal cell; *c*—part of a filament with rhizoid.

ACKNOWLEDGMENT

The author wishes to express his thanks to Dr. Herma Baum-Leinfellner, Botanisches Institut der Universität, Vienna, for her kind help in obtaining the rare work of Biasoletto. He also thanks Prof. Carlo Cappelletti, Instituto ed Orto Botanico, Padova, for the loan of herbarium material.

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Rien n'est souvent plus difficile à détruire qu'une erreur. Cela tient à deux choses: à l'habitude d'abord, puis à la difficulté qu'on éprouve souvent pour trouver l'origine de cette erreur, c'est-a-dire à arriver à la vérité. (Carrière (1867) on synonymy of *P. pyrenaica*, i.e. *P. brutia*).

RELATIONSHIPS BETWEEN *PINUS HALEPENSIS* AND OTHER *INSIGNES* PINES OF THE MEDITERRANEAN REGION *

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ABSTRACT

Turpentines of *Pinus halepensis* from Israel and *P. brutia* from Cyprus were analyzed. Turpentine of the former was found to be strongly dextrorotatory; turpentine of the latter was found to be decidedly laevorotatory. This was in accord with previous findings. Chemical analysis of turpentines of both pines indicated that *P. halepensis* may be characterized by the absence of β-pinene and d-Δ^3-carene; *P. brutia* may be characterized by the presence of these two terpenes. *P. pithyusa*, which is closely related to *P. brutia*, also contains large amounts of d-Δ^3-carene in its turpentine.

The present status of the classification of pines is far from being satisfactory. An excellent monograph on the subject (Shaw 1914) treats it in a rather general way; it lumps together many pines previously considered by botanists as independent species. Although Shaw's monograph still serves a good purpose in the classification of pines, there is urgent need for detailed studies of different groups.

Besides the conventional method of defining a species by external morphological characters alone — genetic, anatomic, and biochemical characters should be taken into consideration. Geographic distribution of a species should be studied — not only the present, but the past as well, for the paleobotanical record often can point to the relationships between existing species.

Chemical methods have also been applied to aid the study of pine relationships (Mirov 1948, 1953, 1953a, 1954). It will suffice here to reiterate briefly findings dealing with turpentines of pines.

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** Maintained by the Forest Service, United States Department of Agriculture, in cooperation with the University of California.

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Geographic Distribution of
PINUS sylvestris and of PINUS halepensis and related species
P. halepensis
P. sylvestris
B P. brutia
S P. sionkewiczii
X unidentified Afghanistan pine apparently close to P. eldarica
P P. pithyusa
E P. eldarica
SCALE
CONIC PROJECTION

Turpentine has been chosen for study because it can be obtained in relatively large quantities even from individual trees. Its composition is remarkably stable throughout the growing season, variations being of a quantitative rather than of a qualitative character. Turpentines are specific. A pine, even when distributed over a large area, always possesses the same major chemical constituents although sometimes in varying proportions. For instance, all varieties of *Pinus ponderosa* contain appreciable quantities of *d*-Δ^3-carene in the turpentine throughout the extensive range of this species (Iloff and Mirov 1954). If a species produces a qualitatively different turpentine in different parts of its range, therefore, it indicates the existence of different varieties of the pine, each one characterized by a stable, apparently genetically fixed, chemical composition of its turpentine (Iloff and Mirov 1954).

When a pine is transplanted from its native habitat to a different environment, the composition of its turpentine does not change (Mirov 1954a, Scheuble 1942). Within a species, each individual tree possesses turpentine slightly different from that of another tree. This individual variability is caused chiefly by varying proportions of different terpenes, such as β-pinene and *d*-Δ^3-carene in *Pinus ponderosa*, or perhaps by varying amounts of two optical antipodes of the same terpene.

When two species cross, the F_1 generation has a mixture of chemical ingredients of turpentines of both parents (Mirov 1954b). The complicated composition of turpentines in subsequent generations or in a hybrid swarm is now under investigation.

Chemical and morphological classifications of pines are not always in accord; it would be futile to rearrange the species according to the chemical composition of their turpentines alone. But in many instances, knowledge of the chemistry of turpentine of a species or variety helps materially in understanding its taxonomic position.

Pines of the group *Insignes* growing in the Mediterranean region offer a good opportunity of applying chemical methods to the elucidation of taxonomic problems.

THE MEDITERRANEAN *Insignes* PINES

According to Shaw (1914) the *Insignes* group of the region is represented by two species: *Pinus pinaster** Ait. and *P. halepensis* Mill. Shaw's *P. halepensis* includes *P. brutia* Ten., *P. pithyusa* Stev., and *P. eldarica*. Related to *P. pithyusa* is *P. stankewiczii* Fom.; this pine is not included in Shaw's monograph.

Pinus halepensis grows in the countries bordering the Mediterranean Sea (see Figure 1). It occurs in Spain, France, Italy, Yugoslavia, Greece, Turkey, Syria, Israel, Morocco, Algeria, Tunisia and Libya.

Pinus brutia is a more restricted species. It is found in Calabria, Italy (ancient Bruttium), in Syria, Turkey, Greece, and in the islands of Chios, Rhodes, Crete and Cyprus. It is distinguished from *P. halepensis* by its straighter trunk, coarser and longer needles, and its spreading or upwards pointing, but never deflexed, cones. The cone peduncle is concealed under the basal cone scales, so that the mature cones appear sessile. *P. halepensis* cones, on the contrary, are conspicuously pedunculate. *P. brutia*

* *Pinus pinaster* grows naturally from Algeria to Dalmatia and from Portugal to Greece. Its turpentine is laevorotatory. It consists of 62.8 percent *l*-α-pinene, 26.8 percent *l*-β-pinene and 10 percent of higher boiling fractions. As *P. pinaster*, even from the most conservative point of view, is a distinct species, never confused with *P. halepensis*, it is not included in the present study.

generally grows at higher elevations than *P. halepensis*. *P. brutia* is resistant to *Matsucoccus* infestation, while *P. halepensis* is susceptible to the attacks of this scale insect. Foresters distinguish between *P. brutia* and *P. halepensis* for practical reasons. Being a better timber tree, *P. brutia* is more often used in afforestation (Papajoannu 1936).

Closely related to *Pinus brutia* are *P. pithyusa*, *P. stankewiczii* and *P. eldarica*. *P. pithyusa* was discovered near Pitsunda (ancient Pithyum) on the east coast of the Black Sea. Later, this pine was found on the island of Prinkipo near Istanbul, in Thrace, in Anatolia, and in Syria. Apparently, the pine growing on the island Thasos, near the coast of eastern Thrace, is also *P. pithyusa* (Papajoannu 1936).

P. stankewiczii was originally described in 1905 as *P. pithyusa* Strangw. var. *stankewiczii* Suk. Using Strangway's name after *P. pithyusa* was an obvious error, as Strangway did not describe this species but merely sent material to Gordon (1939, 1940). This pine is very closely related to *P. pithyusa*. It occurs naturally only in two places on the south coast of Crimea. Extinct *P. sarmatica* Pal., found in the Sarmation stage of the Miocene in the Kerch region of Crimea, is very similar to *P. pithyusa* (Malejeff 1929, p. 138).

P. eldarica Medw. is an endemic pine found only in one locality of Transcaucasia (S. E. of Tbilisi, capital of Georgia). This pine is considered by some (Malejeff 1929) as synonym of *P. brutia*.

A pine found in Afghanistan between Herat and Tebes, and known only by one herbarium specimen, without cones, is apparently closely related to *P. eldarica* (Malejeff 1929).

Relationships between *P. halepensis*, *P. brutia* and the minor *Insignes* pines of the eastern Mediterranean are discussed in detail by Malejeff (1929), according to whom the anatomical structure of needles of *P. brutia* is identical with that of *P. pithyusa* and differs only slightly from that of *P. eldarica*. The anatomical structure of the needles of *P. halepensis*, however, differs considerably from the needle structure of these three pines.

COMPOSITION OF TURPENTINES

Information has been available for some time on the chemical composition of *P. halepensis* and *P. pithyusa* turpentines. *P. brutia* turpentine had been only partially investigated before the present study.

Commercial turpentine of *P. halepensis*, obtained in France and investigated by Vèzes and Dupont (1929), was dextrorotatory ($[\alpha]_D^{25} = +46°$ to 47°) and consisted of 95 percent *d*-α-pinene, 1 percent bornyl acetate, and 4 percent unidentified sesquiterpene. Turpentine of this pine from Spain (Ganuza) was also dextrorotatory ($[\alpha]_D^{25} = +43°$) and consisted of about 94 perecnt *d*-α-pinene. Lacrué (1928) analyzed many samples of *P. halepensis* turpentine from several localities in Spain and compared these with the samples obtained in Algeria, Italy, and Greece. Physical characteristics of all these samples were as follows: $n_D^{14} = 1.4661$ to 1.4669; $d^{14} = 0.8561$ to 0.8590; $[\alpha]_D^{25} = +42.83$ to 48.52. Thus, all samples of *P. halepensis* turpentine, collected in different localities, were dextrorotatory and their specific rotation varied in rather narrow limits, from +42.83° to +48.52°. Older data, giving specific rotation values for this pine of —8.73, +2.84, +1.61, and +0.28, are considered incorrect by Lacrué

because they refer to commercial mixtures of dextrorotatory *P. halepensis* and laevorotatory *P. laricio* turpentine. *P. pithyusa* turpentine analyzed by Arbuzov (1932) was found to consist of about 70 percent *l*-α-pinene, about 24 percent *d*-Δ^3-carene, and 5—6 percent of higher boiling unidentified components.

Very little information is available on the chemical composition of *P. brutia* turpentine. Okay (1940) investigated commercial turpentine of this pine in Turkey, but the results of his investigations are of a very general nature. An anonymous author (1939) described commercial turpentine obtained from "*P. halepensis* from Cyprus" (i.e. from *P. brutia*, as *P. halepensis* s.str. does not occur on Cyprus (Goor 1954)). He reported the following physical characteristics:

Samples	*Turpentine percent*	*Density*	*Index of refraction*	*Optical rotation*	*Specific rotation (calculated)*
1	19.3	0.8682	1.4712	—17.5	—20.2
2	20.9	0.8674	1.4700	—28.0	—32.5

Only α-pinene was identified. It amounted to about 55 percent of the total. Fractions boiling above 160° were not investigated.

EXPERIMENTAL

In 1953, Dr. A. Y. Goor, Conservator of Forests, State of Israel, suggested to the author that a thorough investigation of chemical composition of turpentines of *Pinus halepensis* and *P. brutia* be undertaken (1954): "Such investigation would be desirable from a forester's point of view, as it might lead to the creation of *Matsucoccus* resistant hybrids or even to the development of an efficient insecticide for this insect." To the author, the problem of the relationships between the Mediterranean *Insignes* pines also appealed. Dr. Goor arranged for collecting oleoresin samples of *P. halepensis* from Israel and of *P. brutia* from Cyprus*. The samples were shipped to Berkeley, California, where they were analyzed in our laboratory.

P. halepensis oleoresin was collected in the summer of 1953 in Israel on the slopes of Mt. Carmel. *P. brutia* oleoresin came from compartment No. 17 of the Dhiorios Forest, Cyprus. Turpentine was distilled from the oleoresin in vacuo, so that at the end of the distillation the pressure was reduced to 0.1 mm Hg and the temperature was increased to 180°C. Yield of turpentine of both pines was the same, 20 percent. *P. halepensis* turpentine possessed the following physical characteristics: $d_4^{25} = 0.8575$; $n_D^{25} = 1.4658$; $[\alpha]_D^{25} = +41.25°$. *P. brutia* turpentine was characterized by the following figures: $d_4^{25} = 0.8563$; $n_D^{25} = 1.4612$; $[\alpha]_D^{25} = -28.70°$.

* Thanks are due to Mr. D. F. Davidson, Senior Assistant, Conservator of Forests, Government of Cyprus, for his assistance in procuring oleoresin samples of *Pinus brutia*.

Samples of the two turpentines were fractionated with the aid of a distilling column, 90 cm long and 25 mm inside diameter, enclosed in a heated jacket and packed with glass helices. A 10 to 1 reflux ratio was maintained throughout the distillation.*

Results of the analysis of the turpentines of *P. halepensis* and *P. brutia* were as follows:

P. halepensis turpentine consisted of: 91—92 percent *d-* and *dl-*α-pinene, 2—3 percent myrcene, and 4—5 percent of two apparently distinct sesquiterpenes.

P. brutia turpentine was found to be composed of: 64 percent *l-* and *dl-*α-pinene, 16—17 percent *l-*β-pinene, 13—14 percent *d-*Δ^3-carene, about 2 percent unidentified terpenes, and 4 percent unidentified sesquiterpenes**.

TABLE I

Composition of turpentines of Mediterranean Insignes pines

Species	*Specific rotation (degrees)*	*Major components (percent)*			*Sesquiterpenes*
		α-pinene	*β-pinene*	*d-*Δ^3*-carene*	
P. halepensis, our data	—41.25	86—87	absent	absent	4—5
P. halepensis Vez. and Dup. (1924)	+46 to 47	95	absent	absent	4
P. halepensis Lacrué (1928)	+42.8 to 48.5	—	absent	absent	—
P. brutia from Cyprus, commercial (Anonymous 1939)	—20.2; —32.5	55	—	—	—
P. brutia, our data	—28.70	64	16—17	13—14	—
P. pithyusa from Caucasus (Arbuzov 1932)	— 5.33	70	absent	23.6	—
P. sylvestris (Barrow 1920)***	— 6 to +26****	60—70	17	17	5

DISCUSSION

Our analytical data of *P. halepensis* and *P. brutia* turpentines are shown in Table I, together with previously obtained data. Composition of turpentines of *P. pithyusa* and *P. sylvestris* is given in the Table for comparison. It is seen from the Table that all samples of *P. halepensis* turpentine from different localities of its range are dextrorotatory, and all samples of *P. brutia* turpentine are laevorotatory. Some variation observed among the individual samples may be explained partly by the always present variability within a species and partly by different experimental technique. In general, *P. halepensis* turpentine turns polarized light right, 40 to 50 degrees, and *P. brutia* turpentine turns polarized light left, 20 to 30 degrees.

* Details of the fractional distillation and of the identification of the components of the turpentines will appear in one of the analytical papers on the composition of turpentines, which are being published by the author and his associates, in *J. Amer. pharm. Ass. Sci. Ed.* So far 21 papers have been published.

Laboratory work was conducted under the supervision of Dr. P. M. Iloff, Jr.

** Complete chemical analysis of turpentines of *P. halepensis* from Israel and of *P. brutia* from Cyprus appeared in *J. Amer. pharm. Ass. Sci. Ed.*, 1955, 44, 186—189.

*** *P. sylvestris* is a complex species of the group *Lariciones*. It includes many varieties. In some, α-pinene is absent. *d-*Δ^3-carene was found in all varieties.

**** Various sources.

As to the chemical composition of turpentines of the two pines, α-pinene — a generic* character (Ganuza) — was observed in all samples listed in Table I. This terpene is therefore of little diagnostic value. The minor ingredients also are difficult to evaluate. It is possible that borneol reported in the French sample by Vèzes and Dupont was present in very small quantity in the sample from Israel and thus escaped detection. It is also possible that the myrcene we found in the Israel sample is present in minute quantities in the previously investigated samples. The sesquiterpenes also are found in both species in small quantities, which makes their identification difficult. But when we turn to the two terpenes β-pinene and d-Δ^3-carene, we notice a very pronounced difference between the two pines. The two terpenes are absent in *P. halepensis* turpentine; they are present in the *P. brutia* turpentine in rather large quantity. Of the two terpenes, d-Δ^3-carene perhaps has the better diagnostic value (Iloff and Mirov 1954), because it does not fluctuate so much as β-pinene. Of interest is the fact that d-Δ^3-carene is also found in *P. pithyusa*, *P. sylvestris*, and several southeastern Asiatic and western American pines, but is absent not only in *P. halepensis* but also in the southern European pines, such as *P. pinaster*, *P. nigra*, and, possibly, *P. montana***, and in eastern American pines (Mirov 1954). In this respect, it would be extremely interesting to analyze turpentines of *P. eldarica*, *P. stankewiczii* and the unidentified pine from Afghanistan. The author's guess is that all these three species are d-Δ^3-carene pines. The *P. halepensis* x *P. brutia* hybrid described by Papajoannu (1936) probably also contains d-Δ^3-carene.

It is evident that *Pinus halepensis* and *P. brutia* differ considerably in chemical composition of their turpentines. Are these pines two independent species, or are they mere varieties of the same species? Elevating a variety to a specific rank or demoting a species to a varietal status is so much a matter of botanical opinion that the question is irrelevant. The important fact is that the two sympatric pines, one more widely distributed than the other, possess well established ecological and morphological differences; are distinguished by scale insects which attack one pine but not the other; and finally (as is evident from the analyses of their turpentines), differ in chemical composition of their metabolic products. In our opinion the two should be considered as distinct biological entities.

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* Only four or five pine species do not contain α-pinene in their turpentines (Mirov 1948).
** *P. montana* turpentine has never been analyzed.

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GERMINATION REGULATING MECHANISMS IN SOME DESERT SEEDS.

V. *COLUTEA ISTRIA* MILL. *

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ABSTRACT

(1) The germination of seeds of *Colutea istria* was investigated.

(2) The seeds were found to be largely impermeable to water. This could be remedied either by treatment with concentrated sulphuric acid, or by vigorous shaking in a glass jar. Swelling was more rapid after the former treatment. It was found that, whereas acid treatment removes impermeability by acting all over the surface of the seed coat, the shaking did so only in the micropylar region.

(3) Permeable seeds germinated equally well in light and in dark, and their germination was insensitive to temperature between 20° and 30° C. Seedling growth in dark exceeded that in light.

(4) The two seed samples investigated, which were collected in different years and locations, differed widely in germination. This was apparently caused by different degrees of maturity which the embryos had attained before fruit ripening.

(5) Two separate coats surround the embryo. The inner coat has no influence on germination in the fully "ripe" sample, but in the "unripe" sample it affords the embryo some kind of protection against decay. The outer coat in both samples contains a water-soluble growth inhibitor, which retards embryo growth.

(6) Successful reseeding of depleted desert pastures was carried out with this species in the Negev Highlands. The germination was carried out in a nursery, and two eight-month-old seedlings were transplanted to the field.

INTRODUCTION

Colutea istria Mill. is a bushy perennial leguminous plant occurring in the Irano-Turanian region of southern Israel (Figure 1). The fruit is an inflated indehiscent legume, the seeds being released by the disintegration of the dry, parchment-like coat.

The plant is readily eaten by sheep and goats, and therefore promises to become a valuable asset to arid-zone pasture. The plant branches out from near its base, and may be of great importance in desert agriculture (Evenari and Koller 1955) as a component of bush-dams, which alleviate erosion damage by filtering soil and plant debris from flood waters. The work reported here was carried out as an aid to the contemplated reseeding of desert ranges in the Negev with this species.

Germination in the Leguminosae is controlled in a great many cases by water-impermeable structures surrounding the embryo (Harrington 1916, Porter 1949), which

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Figure 1

A mature plant of *Colutea istria*, growing naturally in the mouth of a small tributary wadi in the Negev Highlands. Two low soil conservation terraces are visible.

consist of certain layers of the seed-coat. These structures normally become permeable only very gradually, thereby scattering germination over extended periods (Harrington 1916, Juby and Pheasant 1933, Barton and Crocker 1948, Porter 1949). They also serve as a hermetic seal, isolating the seed contents from external influences, thereby preserving them and preventing their deterioration (Ohga 1923, Porter 1949).

This impermeability is, of course, a liability in agricultural practice, and various methods have been devised to cause prompt germination in such "hard" seeds (Verschaffelt 1912, Rose 1915, Ohga 1923, Poptzoff 1928, Davis 1928, Hamly 1932, Porter 1935, 1949, Barton 1947, Crocker 1948, Barton and Crocker 1948, Tosa and Isikawa 1951, Crocker and Barton 1953, Cavazza 1953).

MATERIAL AND METHODS

Two samples of dry fruits were collected from the bush: sample A on June 4, 1953, in Nahal Yeter (Wadi Nafikh), and sample B on June 2, 1954, near 'Ein 'Ovdat (Ein Murefiq), both in the Negev Highlands. The fruit-coats were removed and the seeds stored in glass jars. The experimental work was carried out between October 1953 and December 1954.

Germination tests were carried out in Petri dishes on filter paper using tap water. Temperature and light controls were obtained by using illuminated incubators ($\pm$ 0.5°C accuracy). Daily alternating temperatures were obtained by transferring the dishes

from the low-temperature incubator to the high-temperature one for 8 to 9 hours daily. Light intensity was not controlled. Darkness was obtained by placing the dishes in light-tight tins.

EXPERIMENTAL RESULTS

Germination of the seeds of sample A was tested in various light/temperature combinations. In no case did germination exceed 5 percent after 7 days. Only 31 percent of all the seeds had swelled within the first 48 hours. Various treatments were tried in an attempt to find means of increasing swelling percentage and rate. Mechanical scarification was carried out by rubbing the seeds against emery cloth. Impaction treatment (Hamly 1932) was effected by shaking the seeds in a glass jar in a mechanical bottle-shaker for 30 and 60 minutes, respectively. Chemical scarification was carried out by immersing the seeds in concentrated H_2SO_4 for 15, 30, and 60 minutes, respectively (with frequent stirring), then washing them thoroughly. Most of the swelling in acid-treated seeds took place within 2 to 4 hours, but in impacted seeds swelling was gradual, and extended over 48 hours. Swelling percentages after the various treatments are presented in Table I.

TABLE I

Swelling percentages of C. istria seeds after various treatments

Treatment	*Duration in minutes*	*Swelling percentage*
Impaction	30	41
	60	44
Mechanical scarification	—	45
Concentrated H_2SO_4	15	41
	30	98
	60	98

The above results indicated that 30 to 60 minutes' treatment with concentrated sulphuric acid was optimal for abolishing impermeability.

Acid treatment, though effective, leaves the seeds moist, which is undesirable for sowing under field conditions. Storage of seeds thus treated might also impair their germinability. It was, therefore, decided to try to improve the response to impaction by lengthening the duration of treatment. It was found that vigorous shaking was effective in reducing impermeability, but the results showed marked variability, unless vigorous shaking was applied for 6 hours. Of four lots of 250 seeds each (sample B) given this treatment (6 months after harvest) 90.3 ± 7.8 per cent swelled within 18 hours after moistening.

In order to compare the mode of action of acid and impaction treatments on the permeability of the seed coats, the following experiments were carried out.

The seeds used belonged to sample B. One portion was acid treated for 45 minutes, while another portion was subjected to impaction treatment for 5 hours. Plates of soft plasticine were placed in the bottoms of four Petri dishes. Seeds from the two treatments were partially embedded into the plasticine in two ways: (1) with the micropylar

edge (including the hilum and raphe) inside the plasticine, (2) with the micropylar edge free. The dishes were then filled with tap water and left in the laboratory. The acid-treated seeds swelled rapidly, most of the swelling taking place within 2 hours. The impacted seeds, on the other hand, swelled only gradually during 48 hours. Swelling percentages after 65 hours are presented in Table II.

TABLE II

Swelling of C. istria seeds after various treatments and under various conditions

Treatment	*Position of micropylar edge*	*No. of seeds used*	*Swelling percentage*
Concentrated H_2SO_4	Free	32	90.8
	Embedded	24	83.0
Impaction	Free	42	88.0
	Embedded	42	9.5

The germination of seeds from sample B (6 months after harvest), made permeable by 6 hours' impaction, was tested at 20°C, 26°C, 30°C, and at a daily alternation of 20°/30°C in both light and dark. Light and dark germination was carried out in seeds which had been previously imbibed in light and dark respectively. Two lots of 25 seeds each were used per test. Average germination percentages of the swelling seeds after 4 days were all between 94 and 100 per cent, under all germination conditions. On the other hand, seeds of sample A ($8\frac{1}{2}$ months after harvest), made permeable in a similar manner, germinated poorly under the same conditions, final germination percentages of the swelling seeds showing great variability, and never exceeding 55 per cent.

The causes for the dissimilarity between the two samples were investigated. Upon dissection of the seed, two separate coats surrounding the embryo could be distinguished. The outer consisted of a thin, leathery, brown membrane, while the inner was thicker, colourless and transparent. The inner coat was the only one to swell, and it presented a hyaline appearance upon swelling.

The striking difference between the seeds from the two samples was found in the embryos. While in seeds from sample A 97.9 per cent (465 out of 475) of the embryos were yellow and the rest green, in seeds from sample B only 39.8 per cent (65 out of 163) were yellow and the rest green.

The following experiments were carried out in order to determine any differences in the physiology of the two types of embryos in sample A. Seeds which had been made permeable by shaking were imbibed, and the outer coat removed. They were then separated into yellow and green (the colour of the embryo could be clearly seen through the transparent inner coat). The two types were then subjected to four different conditions of germination, as follows (at least two lots of 25 seeds each per treatment):

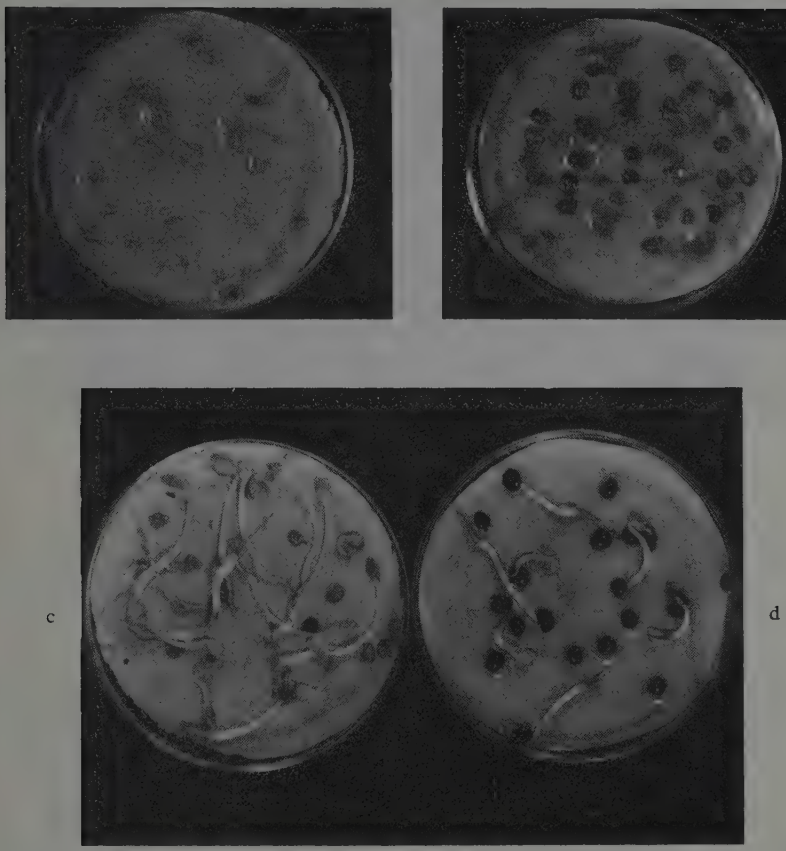

Figure 2

Germination and development of seedlings of *C. istria* from sample A. *a* — Naked yellow embryos; note that, though there is some germination, there was hardly any development before total decay had set in. *b*—As in (*a*), but in presence of discarded inner coats; note that the latter have no influence on seedling behaviour. *c*—Yellow embryos with intact inner coat. *d*—Intact seeds; low germination probably resulted from the large percentage of green embryos; note that the germinated seedlings are less developed than in (*c*).

1. Embryos germinated with inner coat intact.
2. As in 1, but in presence of discarded outer coat.
3. Inner coat removed.
4. As in 3, but in presence of discarded inner coat.

Intact permeable seeds were used as controls.

Germination was carried out at 20°C in the dark. Within five days it was observed that (a) all naked embryos had decayed (Figure 2 *a*), irrespective of colour of embryo, or presence of the discarded inner coat (Figure 2 *b*); (b) embryos with intact inner coats had germinated equally well in presence, or in absence, of discarded outer coats, but, while the yellow embryos had germinated to an average of 86.5 ± 2.5 per cent, only 43 ± 1.0 per cent of the green embroys had germinated; (c) though embroys with intact inner coats had germinated equally well in presence or in absence of discarded outer coats, seedling growth (elongation) was visibly retarded by the presence of the outer coats (Figure 2 *c* and *d*).

These differences in growth were subjected to statistical analysis. Since the differences in growth were observed in both yellow and green embroys, and because of the relatively small number of seedlings obtained from green embryos, the statistical treatment was carried out only on seedlings from yellow embryos. Seven-day-old seedlings were divided into lots of five. Excess water was blotted off, and the lots weighed rapidly on a torsion balance. Mean fresh weights per lot from the different treatments and the significance of the differences between the various treatments are given in Table III.

TABLE III

A. Mean fresh weights of lots of 7-days' old C. istria seedlings (from sample A) from various germination conditions (5 seedlings per lot)

Conditions of germination	*No. of lots*	*Mean weights per lot (mg)*	*Standard error*
1. Intact seeds	3	218	± 45
2. Seeds with inner coat, in presence of outer coat	8	261	± 58
3. Seeds with inner coat only	7	430	± 110

B. Significance of the difference between the various germination conditions

Conditions compared	*"t"*	*P*	*Significance*
1 and 2	1.303	0.2 — 0.3	nil
2 and 3	3.674	0.01 — 0.001	high
1 and 3	4.326	0.01 — 0.001	high

The same experiments, repeated in light, had similar results, with minor differences (no statistical treatment carried out).

In seeds from sample B the previous experiments could be repeated only with yellow embryos, since they contained a very low percentage of green embryos. Seeds that were made permeable by impaction were imbibed and treated as in the previous experiment (two lots of 25 seeds each were used per test). Germination was carried out simultaneously in light and in dark at 20°C. Within two days, 96—100 per cent of the embryos (and seeds) had germinated under all conditions, and none had decayed. However,

Figure 3
The effects of outer coats of *C. istria* on the germination of lettuce seed (var. Progress).

differences in development were evident between seedlings from the various treatments. These differences were subjected to statistical analysis as before.

Mean fresh weight per lot from the different treatments is presented in Table IV.

TABLE IV

Mean fresh weights of lots of 6-days' old C. istria seedlings (from sample B) from various germination conditions (5 seedlings per lot, 8 replicates)

Treatments		*Light*	*Dark*
I.	Naked embryos	483.13	590.63
II.	Naked embryos + inner coats	309.75	463.88
III.	Embryos with intact inner coats	471.13	646.00
IV.	As in III + outer coats	424.63	530.38
V.	Intact permeable seeds (controls)	411.13	560.00

Analysis of variance of the results (Paterson 1939) showed that for a probability of 1 per cent a difference between mean weights in light and in dark greater than 32.51 mg, and a difference between mean weights in the other treatments greater than 45.95 mg, are significant.

From these results the following observations may be made:

(a) Seedling development in the dark was significantly greater than in light.

(b) The presence of the outer coat significantly retarded seedling growth.

(c) Seedling growth in light was unaffected by presence of intact inner coat, and in dark it was even slightly promoted. The presence of the discarded inner coat, on the other hand, retarded seedling growth in both light and dark.

The above observations indicated the presence of some inhibitor in the outer coat of seeds of both samples. Preliminary investigations showed that a dilute, cold water extract from seeds which had been rendered permeable by impaction had no effect on germination percentage of lettuce seeds (var. Progress) at 20°C in the dark. Seedling development, on the other hand, was greatly inhibited by the extract, growth ceasing when the radicle had projected one to two millimetres from the seed, with evidence of browning and necrosis of the root-tip (Figure 3).

The inhibitor, whose presence was thus demonstrated, was further investigated, using higher concentrations. One thousand impaction-treated seeds were placed on moist cotton wool, and allowed to swell. Seeds that had started to germinate were removed when found, the remainder removed at the end of 7 days. The brown extract in the cotton wool was quantitatively removed (final volume 212 ml) and divided into two portions, both of which were reduced to approximately half their original volume, one portion over a water bath, the other by vacuum dehydration. Lettuce seeds (var. Progress) were germinated in various dilutions of these extracts (20°C in the dark), two lots per dilution. Average germination percentages after 96 hours are presented in Table V.

TABLE V

Germination of lettuce seeds (var. Progress) in various concentrations of extract from imbibed, intact C. istria seeds

Extract concentrated by	*Dilution*					*Water control*
	1	0.5	0.25	0.125	0.0525	
Heat	65.5	82.0	84.5	82.5	83.0	86.5
Vacuum	0.5	54.5	77.0	85.5	77.5	

These results indicated the possibility that the inhibitor diffusing from the outer coats of *Colutea istria* may be thermo-labile.

As the germination requirements of the seeds of *C. istria* had been worked out, experimental reseeding with this species was attempted. The tests were carried out in cooperation with Mr. D. Bogoslav of the Ministry of Agriculture, in the nurseries of the Desert Research Institute at Beersheba, during the winter of 1953/54, and repeated at intervals between April and November 1954. The seeds were treated in concentrated sulphuric acid for one hour, then thoroughly rinsed to remove excess acid and traces of the inhibitor, and finally planted in tin cans filled with loess soil in which *C. istria* is native. Good emergence was obtained under the conditions existing in the various planting seasons, the average percentage fluctuating between 65 and 85 per cent. It was found that for such nursery practices the warmer seasons of the year were more favourable for seedling development. Two to eight months old plants, which were raised in the nursery, were transplanted to the field near the settlement of Sde Boqer in the Negev Highlands, and planted in soil conservation projects as reinforcement for dykes and terraces (Evenari and Koller 1955). The planting was carried out after the soil

had been moistened by a flash-flood in late December 1954. It was found that the older plants had less difficulties in establishment than the younger ones. Though good establishment was obtained, it is still too early to assess the results, especially as the winter of 1954/55 was extremely dry, and the plants had to receive additional irrigation in order to keep them from dying off.

The results of the field experiments seem to indicate that such a method of propagation for *C. istria* is quite feasible.

DISCUSSION

Permeability of the seeds

The fact that untreated seeds of *C. istria* do not germinate well was shown to be a result of an impermeable seed coat. Various methods for increasing permeability were successfully tried, and it was found that 30 to 60 minutes' treatment with concentrated sulphuric acid, or 6 hours' vigorous shaking of the dry seeds in a glass jar, were sufficient to eliminate impermeability almost entirely. These latter results are in full accordance with the description given by Hamly (1932) of leguminous seeds, the permeability of which is favourably affected by impaction. The outer coat in such seeds is watertight and is described as being pierced in only one place by a "strophiolar cleft", usually plugged by suberin. The action of the impaction is supposed to loosen and dislodge this plug.

Detailed microscopic examination of the coats of *C. istria* was not undertaken. However, two facts support the supposition that in *C. istria* we probably have a similar structure to that described by Hamly (1932) for *Melilotus alba:*

(1) Swelling after impaction was gradual and comparatively slow, when compared to acid-treated seeds. This lends strength to the assumption that, whereas impaction would only remove the "plug" and allow a gradual penetration of water through the cleft, the acid treatment would remove impermeability all over the surface of the seed simultaneously and facilitate a much faster water uptake.

(2) The blocking of the micropylar region by a water-impermeable substance (plasticine) blocked water uptake in impacted seeds, and did not do so in acid-treated seeds (Table II). This shows that, while impaction has effects only on the micropylar region, the acid acts on other portions of the coat surface. It must, however, be stated that the results do not permit the exact definition of the path of water entry into impacted seeds, as the embedding blocked not only the micropylar region itself, but also the raphe and the hilum.

The fact that seeds of *C. istria* react favourably to impaction is in full accordance with the results of Barton (1947) for seeds of other plants belonging to the same subfamily (Papilionatae) of the Leguminosae.

Difference in behaviour of the seeds from the two samples

Water-permeable seeds of the two samples exhibited a marked difference in germination. This could arise from several different causes. One possibility was that the seed coats exerted different influences in the two samples. The other possibility was that the fault lay within the embryo itself.

As will be discussed below, the first possibility, namely that the differences between the two samples resided in the seed coats, was found to be unlikely. On the other hand, the large percentage of green embryos with low germinability in sample A indicates that the underlying cause for the low germination in this sample might reside within the embryo. The fact that naked embryos of this sample, including the yellow ones, had all decayed, while naked embryos of sample B developed quite normally, lends strength to this assumption.

It would seem that sample A, containing, as it does, a large proportion of green embryos, and having, in general, embryos of low viability, might have been immature. However, the seeds were collected from entirely dry fruits, and seemed, externally, to be as ripe as those in sample B. It is quite likely that, under the uncertain climatic conditions in which this plant exists, the course of embryo maturation might have been disturbed before completion.

One of the conclusions which might be drawn from this is that great caution should be practised in using seeds of this species, collected in the field, for reseeding purposes.

Light and temperature

Germination percentages of seeds from both samples were unaffected by conditions of illumination and by temperature (in the range 20—30°C). These results indicate that seeds of *C. istria* would germinate over a relatively wide temperature range, and equally well in light and in darkness, as soon as their coats become, or are made, permeable. However, the results in Table IV show that light retards seedling growth. This growth retardation, which was observed in decreased length and fresh weight of the seedlings in light, may be a result of effects of etiolation on the seedlings growing in the dark.

Effects of the seed coats

Dissection of the seeds showed the presence of two discrete seed coats. Removal of the outer coat from water-permeable seeds promoted seedling growth (Tables III and IV). This could be a result of some mechanical obstacle which this coat offers to gas exchange or to the expansion of the embryo early in germination, or a result of inhibitors which it contains. However, these same tables show that the outer coats caused the same inhibition whether they were intact around the embryo, or only present in the germination bed with the seeds from which they had been removed (see next section). This indicates that these coats retard growth only through the growth inhibitors which they contain.

The inner coat seems to have no effect on germination or seedling growth in seeds of sample B, when it is intact and encloses the embryo. On the other hand, the discarded inner coat retarded seedling growth. The reason why the inner coat, which has no effect on growth when intact, would retard growth when in presence of naked embryos, is not clear. Possibly, when this coat is removed and its interior exposed to air, it excretes some toxic products.

In seeds of sample A, the presence of the intact inner coat seems to have some protective influence on the embryo, since naked embryos had all decayed, and embryos with this coat intact had survived and germinated normally.

Inhibitors

The presence of the discarded outer coats did not influence germination percentages in *Colutea* and in lettuce (except in very high concentrations), but it strongly inhibited seedling growth. These results show that the outer seed coats of both samples contain a water-soluble inhibitor which retards growth (see also Evenari 1949). The results in Table V show that this inhibitor is apparently somewhat thermo-labile, and active only in high concentrations.

The results in Tables III and IV show that the outer coat retards growth both when intact and detached. The difference in fresh weight between seedlings which had germinated from intact seeds and those which had germinated in the presence of the detached outer coats, is insignificant, while the difference between the weight of seedlings which had germinated in total absence of the outer coat, and that of seedlings which had germinated under its influence, is highly significant. This indicates that the outer coats retard growth solely through their growth-inhibitor content, and not through other effects.

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THE REGULATION OF GERMINATION IN SEEDS (REVIEW)

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GENERAL

The phenomenon of inhibited or delayed germination is a very widely known one, especially among uncultivated species (Crocker 1916, E. H. Toole 1936, Barton and Crocker 1948, Bibbey 1948, Porter 1949, Evenari 1949, Crocker and Barton 1953), but its ecological significance has not been much discussed.

The seed and its germination, respectively, are the basic means and ways for the propagation of the species. The fundamental rôle which germination plays in the existence of annual plants is reasonably clear, since their establishment depends entirely on an uninterrupted sequence of generations.

In the existence of long-lived perennials, on the other hand, germination seems to occupy a position of secondary importance. However, even perennials are confronted with major problems of extinction through (a) competition, (b) ageing and disease, (c) gradual or catastrophic changes which continuously occur in the conditions of the habitat. Individual vigour and resistance to adverse conditions no doubt assist in overcoming these forces of extinction, but their effectiveness is secondary when compared with that of a well-organized propagation mechanism, operating on the principle "*Cast thy bread upon the waters: for thou shalt find it after many days*" (Ecclesiastes XI : 1).

The basic principle of the perpetuation and the expansion of the species via propagation by seeds is the regular production, in each reproductive season, of large crops of viable seeds, with efficient means for widespread dispersal. However, if all seeds which are produced germinated promptly this would constitute a "hit or miss" method, very wasteful of precious propagation material. Cuts in this waste are achieved in at least two ways. One way is the equipping of the seed with a "delayed action" mechanism, which permits it to attain germinability only gradually, combined with an extended life-span. This causes "dispersal in time" of germination, analogical to the "dispersal in space" of the seeds. The other way is the equipping of the seed with mechanisms which restrict germination to such a combination of ecological conditions as will ensure the maximal chance for the germinating plant to mature and reproduce, the while maintaining viability in the non-germinated seeds.

This review is intended to summarize the recognized relationships between germination and the various factor which regulate it.

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THE VARIOUS GERMINATION REGULATING FACTORS

Moisture

All seeds require ample hydration in order to germinate, but availability of moisture varies according to habitat and climate. Most vegetable seeds give good germination over the entire range of available water, and seem to fall into four groups based on their ability to germinate near the wilting percentage (Doneen and McGillivray 1943). High moisture tensions in the soil at time of germination often prove to be a limiting factor in the germination of some species (Bibbey 1948, Ayers 1952). The maximal moisture tension permitting germination appears to be specific for each species of seed, but for a given seed species it is equal in all soils (Ayers 1952, Hunter and Erickson 1952). The critical level of moisture tension at which germination of wheat is completely inhibited was not reached even at a tension of — 320 m of water (pF = 4.5) which is below wilting point. Rate of germination is, however, slowed down under such conditions (Owen 1952). Germination response of some species improves upon increase of the moisture tension (Cavazza 1953b). Seeds of different varieties of maize and cotton exhibited hydric, mesic and xeric germination responses, which fitted in well with conditions existing in their natural habitat, these responses being shown in the moisture requirements of the plumule, and the imbibition of the cotyledons and endosperm (E. Stiles 1948).

Moisture "conditioning" of the "dry" seeds often determines their subsequent germination. Alternate soaking and drying prior to germination was found to be favourable for various pasture plants (Griswold 1936), *Dactylis glomerata* (Chippindale 1933), *Cichorium endivia* (Thompson 1946) and lettuce (Thompson and Horn 1944). Presoaking for several days was found favourable for the germination of *Buchloe dactyloides* (Wenger 1931). Predrying the seeds prior to germination was found not to affect germination percentage in several species (Harrington and Crocker 1918), while in *Poa pratensis* (Pickholz 1911) and in several other species (Steinbauer and Steinbauer 1931, Went and Munz 1949, Koller 1954) predrying the seeds increased their subsequent germination. Seeds of many species, such as *Kochia indica* (El-Shishiny 1953), maintain their viability only when stored in a desiccated condition. Germination of seeds of *Taraxacum kok-saghyz* was greatly promoted by allowing them to imbibe water from a medium the moisture tension of which was too high to permit germination, and then drying them prior to germination (Levitt and Hamm 1943). Seeds of different species also reacted differently when germinated under water (Morinaga 1926a). In some desert species from the U.S.A. (Went 1949) and from Israel (Soriano 1953) germination was found to be closely correlated with amount and duration of the artificial rain to which the seeds were subjected prior to subirrigation.

It thus appears that the germination of a large number of species reacts to a more or less strict set of moisture conditions, either during actual germination, or prior to it. Such reactions no doubt play their part in restricting germination to habitats in which moisture conditions are suitable for the whole life cycle of the species. That this is indeed the case has been proved in several of the above-mentioned cases, where a close correlation was found between the reaction of germination to moisture and

the moisture conditions of the natural habitat of the species. More work is, however, necessary to confirm the general applicability of this correlation.

Gases

Seeds of different species react differently when germinated in various mixtures of atmospheric gases. These different reactions seem to play a major part in the biology of weed establishment: although the germination of both weed and agricultural seeds was strongly inhibited by sub-optimal oxygen and supra-optimal carbon dioxide, only the agricultural seeds deteriorated under such conditions, while the weed seeds remained in a state of "environmental dormancy" for a long time, and germinated promptly as soon as gas conditions permitted (Bibbey 1948).

The best example of the influence of oxygen concentration is supplied by *Xanthium*, in which the upper and lower seeds differ greatly in their oxygen requirements for germination, the requirements being strongly affected by the germination temperature (Crocker 1096, Shull 1911, Thornton 1935).

Besides being correlated with temperature, the oxygen requirements for germination seem to be also correlated with conditions of illumination during germination: light-inhibition in *Nigella* and *Phacelia tenacitifolia* was reduced by increased oxygen pressure, and dark-stimulation in seeds of *Epilobium hirsutum*, *Lythrum salicaria*, and *Nicotiana tabacum* was reduced in proportion to the increase in the concentration of oxygen, the reduction being compensated by increasing light intensity (Boehmer, 1928).

In several species, like *Rumex crispus*, carrot (Gardner 1921), spinach (Sifton 1927), and *Tilia americana* (Barton 1934, Spaeth 1934), increased oxygen furthers germination. In other species, like *Nelumbo nucifera* (Ohga 1926) and *Scirpus* spp. (Isely 1944), germination is unaffected by increased oxygen concentrations. On the other hand, the germination of *Typha latifolia* and *Cynodon dactylon* is greatly stimulated by dilution of the air with 40% inert gas, but this beneficial effect of reduced oxygen pressure is noticeable only in intact seeds, the naked embryos being unaffected (Morinaga 1926c). Naked embryos of *Alisma plantago* (Crocker and Davis 1914) and *Peltandra virginica* (Edwards 1933) germinate well in total absence of oxygen, but, whereas further development in seedlings of the former is inhibited by the unaerobic conditions, the coleoptile of the latter enlarges to double or three times the size it would have attained under aerobic conditions.

Carbon dioxide is a metabolic waste product, and it might be expected, therefore, that its presence would inhibit germination. However, it apparently takes unusually high concentrations of this gas to cause inhibition, although the inhibiting concentrations drop with the lowering of temperature (Thornton 1944). What is surprising is that in quite a few cases carbon dioxide does actually promote germination. This is true for freshly harvested lettuce seeds at supra-optimal temperatures (Thornton 1936), for coated *Xanthium* seeds (Thornton 1935), and for *Poa compressa* (Anderson 1933).

The rôle these two gases play in the metabolism of germination is obscure at present, because they seem to affect germination not only through respiration.

The composition of the air above the soil is relatively very stable. The composition of the soil atmosphere, on the other hand, varies within extremely wide limits, and is greatly influenced by soil physical conditions, soil population, soil depth, and season of the year. It is not surprising, therefore, that seeds, whose natural environment is nearly always the soil interior, should react much more strongly to relatively small changes in the composition of the air than do aerial parts of the plants. In this respect the work on weed seeds (Bibbey 1948) and on the dimorphic *Xanthium* (Crocker 1906, Shull 1911, Thornton 1935) takes on a high biological significance. Even more significant are the ecological implications of the instances of favourable effects of increased oxygen on several land plants, of the insensitiveness to oxygen of some water plants (Ohga 1926, Isely 1944), and of the stimulating action of reduced oxygen in other water plants (Crocker and Davis 1914, Morinaga 1926c, Edwards 1933).

Temperature

Temperature effects in germination have been very widely investigated and reviewed (e.g. V. K. Toole 1938, 1941). The optimal temperatures for germination vary from species to species, and sometimes even from variety to variety, especially in newly harvested seeds (Toole and Toole 1939, W. Stiles 1950, Crocker and Barton 1953). Cases are even known of dimorphic seeds having different temperature optima for germination (Crocker 1906).

For most seeds the optimal temperatures for germination may range between 15° and 35°C, but there are several reports of lower (Sifton 1927, Aamodt 1935, Schroeder and Barton 1939) and higher (Kadman 1954) optima. These temperature optima usually correspond quite well to temperature conditions that exist in the natural habitat at the time of normal germination (Went and Westergraad 1949). On the other hand, there are quite a number of species whose germination is relatively insensitive to temperature within the range of germination temperatures (V. K. Toole 1938, Schroeder and Barton 1939, Gordon 1951).

In many species germination is greatly promoted by temperatures which alternate diurnally so that a long period at low temperatures alternates with a short one at higher temperatures (Gardner 1921, Harrington 1923, Morinaga 1926b, V. K. Toole 1938, 1941, Toole and Toole 1941, Benedict and Robinson 1946). This is especially the case with freshly harvested seeds (E. H. Toole 1939, Toole and Toole 1940). It is still uncertain whether the alternating temperatures affect germination through their action on the embryo itself, or on the coats which surround it (Morinaga 1926b, Went, in Murneek and Whyte 1948).

In addition to constant and daily alternating temperatures, seasonally alternating temperatures seem to have a profound effect on germination, particularly on that of species from temperate zones. Such seeds that require a period of "stratification" (i.e. moist cold-storage) in order to germinate have been considered as physiologically unripe at time of dispersal, and hence incapable of germination. The process that takes place during stratification has, therefore, been termed "after-ripening".

Various facts tend to show that "after-ripening" is an unjustified and uncalled-for term, since stratification does not actually entail a further ripening of an unripe embryo, but rather the onset of a somewhat lengthy germination of an embryo requiring seasonally alternating temperatures for germination. First, stratification is effective only when carried out under moist conditions (Haut 1932, 1938, Evenari et al. 1947, 1948). Secondly, whereas drying the seeds before stratification has no effect on their "after-ripening", drying after stratification completely offsets any "after-ripening" effects (Haut 1932, 1938, Evenari et al. 1948). Finally, if stratification is carried out long enough, some seeds may even germinate during "after-ripening" (Crocker 1928, Joseph 1929, Giersbach and Crocker 1932, Evenari et al. 1948). This type of seed is quite frequent (Davis and Rose 1912, R. C. Rose 1919, Weiss 1926, Barton 1929, 1930, 1932, 1936a, Baldwin 1930, Crocker and Barton 1931, Giersbach and Crocker 1932, Muenscher 1936, Flemion 1937a, b, Giersbach 1934, 1937c, Schroeder 1937, Isely 1944, Evenari et al. 1947, 1948), and more examples may be found summarized elsewhere (Barton and Crocker 1948, Crocker 1948, Crocker and Barton 1953).

In all the above-mentioned cases the embryo seems to be completely developed at time of seed dispersal. In other cases, like *Fraxinus nigra* (Steinbauer 1937) or *Ilex opaca* (Ives 1923), the embryo, at time of seed dispersal, is rudimentary, and has to undergo a period of moist storage at 20°C, during which it grows and fills up the seed coat. At this stage the embryo is ready to respond to stratification. Seeds of other species of *Fraxinus*, which contain mature embryos at time of dispersal, can respond to stratification straight away. Only seeds of the *Fraxinus nigra* type may be correctly termed "non-after-ripened".

The germination types so far described react to a two-season temperature alternation (winter—spring), with the exception of *F. nigra* which reacts to a three-season alternation (fall — winter — spring). A different type of response to a three-season alternation is exhibited by the seeds of plants with "epicotyl dormancy", where the radicle commences growth at intermediate temperatures, but epicotyl growth takes place only when a period of stratification follows the completion of radicle growth (Barton 1933, 1936c, Giersbach 1937b, Barton and Crocker 1948). An analogical case of response to a three-season alternation is that of seeds, the embryos of which react to a two-season alternation, but which are contained in an impermeable coat that has to be rendered permeable by a period of moist high-temperature storage before stratification can be successfully carried out (Giersbach and Barton 1932, Flemion 1933a, 1934a, 1937b, Barton 1934, 1951, Spaeth 1934, Giersbach 1934, 1937a, Flemion and Parker 1942).

The most complex type of temperature demands is exhibited by seeds with "double protoplasmic dormancy" (Barton and Crocker 1948). In these seeds protrusion of the radicle takes place only after stratification, and the epicotyl starts its growth only after a second stratification has followed a certain amount of root growth (Barton and Schroeder 1942, Barton 1944, Barton and Crocker 1948). This, then, appears to be a type of germination requiring a six-season alternation.

Quite a different type of response to stratification in some seeds is the gradual decrease in the strictness of the conditions required for their germination. Temperature

limits for germination become wider, and there is generally a shift in the optimum (Weiss 1926, Joseph 1929, Barton 1935). The duration of effective stratification sometimes decreases with increasing age of the seed (Toole and Toole 1941).

The processes occurring during this type of stratification are apparently not the same as those occurring in seeds responding to seasonal temperature alternations. The former require very specific germination conditions, but they nevertheless do germinate under those conditions without stratification, whereas the latter do not germinate at all unless stratified. In the former the need for stratification gradually passes with age (Kroeger 1941), or it may be satisfied by other treatments (Giersbach and Crocker 1929, Justice 1941, Toole and Toole 1941), while in the latter neither occurs (Flemion 1931, Tukey and Carlson 1945). Finally, the effective stratification in the latter case is of a much longer duration.

The metabolic changes taking place during stratification in seeds which respond to seasonal alternation have been widely investigated and summarized (Crocker and Barton 1953). Two significant facts stand out from these data. First, non-stratified embryos appear to have difficulties in water absorption and transport (Flemion 1931). Secondly, forcing non-stratified embryos to germinate produces dwarf plants which resume normal shoot growth only after the dwarfs have been stratified (Flemion 1933b, 1934b, Steinbauer 1937, Scott and Ink 1950). These dwarfs arise as a result of some form of inhibition residing in the shoot apex (Flemion and Waterbury 1945). It appears that during stratification there occurs a gradual disappearance of inhibitors from the storage tissue of the seed (Cox 1942).

Very strong correlation often exists between the temperature requirements and the age of the seed. Freshly harvested seeds often have very strict temperature requirements, germinating only within a very narrow range of temperatures, or only in a daily alternation of temperatures, but, with the passage of time, this specificity disappears and germination may occur within a wide range of temperatures (Kearns and Toole 1939, Toole and Toole 1939, 1940, E. H. Toole 1939, Barton 1945, Akamine 1947, Barton and Hotchkiss 1951, Gordon 1951, Chandler 1953).

We have seen that a good correlation usually exists between habitat and the requirements for a germination temperature. This is especially evident in species which require alternating temperatures.

Seasonally alternating temperatures which include a prolonged low temperature period are found in the temperate zones of the earth and at high elevations elsewhere. For plants which inhabit such climatic regions the survival value of a germination regulating mechanism which requires a seasonal temperature alternation is obvious. Such a mechanism ensures that no wasteful germination can take place before the hard winter has passed. It seems, therefore, that a requirement for a seasonal temperature alternation would determine, via germination, the geographical distribution of the species. Likewise, a requirement for a diurnal temperature alternation would seem to confine germination not only to the geographical region where such alternations occur, but, at the same time, also to the season when they occur in the soil. Thus, the requirement for alternating temperatures, whether diurnal or seasonal, may be

considered as one of the regulating mechanisms which most efficiently ensure a chance for the germinating plant to complete its life cycle.

Those cases where a gradual decrease in strictness of the temperature requirements for germination occurs during stratification or dry storage, may also be interpreted as a "delayed action" mechanism whereby seeds are prevented from germinating until they had passed a definite period under a definite set of conditions. This would tend to make the advent of maximal germinability coincide with the season most suitable for the starting of the life cycle.

Mechanical factors in the coats enclosing the embryo

These may be divided into (a) coats which regulate gas exchange between the embryo and the surroundings, (b) coats which regulate water exchange between the embryo and its surroundings, (c) coats offering mechanical resistance to the expansion of the growing embryo, and (d) coats of selective permeability.

Such structures are made up of various plant organs or tissues. In most cases the structure is contained in the seed coat (Shull 1913), but sometimes more internal tissues, such as parts of the nucellus (Van der Marel 1919, W. E. Davis 1930, Spaeth 1934) or endosperm (Borthwick and Robbins 1928, Evenari and Neumann 1952) are responsible. Quite often it is found that structures external to the testa are responsible, such as certain layers of the fruit coat (Lavialle 1929, Ransome 1935), or even paleas and glumes (Anderson 1932), bracts (Benedict and Robinson 1946, Beadle 1952), and neighbouring florets (Benedict and Robinson 1946).

(a) Coats which regulate gas exchange. The most familiar case is that of *Xanthium* seeds, especially the upper seed, where the seed coat, though permeable to water, is relatively impermeable to oxygen (Crocker 1906, Shull 1911, Thornton 1935). Seeds of *Ambrosia trifida* (W. E. Davis 1930), *Tilia americana* (Spaeth 1934), and potato (Stier 1937) do not germinate because a single layer of live nucellar tissue which encloses the embryo is impermeable to oxygen. In *Cucurbita pepo* there are two seed coats surrounding the embryo, both relatively impermeable to gases. The outer is the less permeable of the two, but since it is pierced by the micropyle it is the less effective. The permeability of the inner coat towards carbon dioxide may be changed by heating, imbibition, or chloroform vapours, but its permeability towards oxygen and nitrogen remains unchanged by these treatments (Brown 1940). In lettuce a cuticular membrane separating the endosperm from the testa is relatively impermeable to carbon dioxide at high germination temperatures (Borthwick and Robbins 1928). A testa impermeable to oxygen is known in *Fraxinus pennsylvanica* (Cox 1942). An interesting case is known in *Guayule* seeds. The achene is impermeable to water and becomes permeable gradually through the oxidizing action of air. This oxidation lasts a whole year in the intact dispersal unit, but only six months when the sterile florets and bracts have been removed. These structures apparently reduce the access of air to the achene (Benedict and Robinson 1946).

Several investigators (Lavialle 1929, Thornton 1945) are of the opinion that gas regulating structures play an important part not only in actual germination, but also

in the creation of "dormancy" by restricting gas exchange during embryo development, thereby causing the formation of narcotic metabolic by-products of anaerobic respiration. This assumption seems to be borne out by the fact that after-ripening in dry storage of seeds of *Polygonum* species is retarded by a restriction of oxygen entry through the pericarp (Justice 1941, 1944).

(b) Coats which regulate water-exchange. These are modifications of great survival value for the species, first, since they scatter germination over extended periods (Harrington 1916, Juby and Pheasant 1933, Barton and Crocker 1948) and secondly, because the hermetic sealing of the seed contents ensures their preservation for long periods, even under adverse external conditions (Ohga 1923, 1926, Porter 1949), a deduction from the fact of the rapid deterioration of germinability during storage in seeds which had been made permeable.

In nature, there are several ways in which these structures become permeable. One of the most common ways is through attack by soil micro-organisms, which occurs upon high temperature moist storage in soil or granulated peat moss. That it is the action of micro-organisms and not of the storage conditions by themselves has been proved for *Symphoriocarpos racemosus* (Pfeiffer 1934). This method of becoming permeable is abundant in seeds requiring seasonal temperature alternations (see section on temperature), and adds another season to the number the embryo itself requires.

In several species the seeds become permeable through pure climatic influences, some species reacting to high temperature moist storage (Jones 1928), others to winter conditions (Martin 1922), while still others do so during frost (Midgeley 1926).

In several species the impermeability of the coats is removed in prolonged dry storage (Lute 1928). The changes taking place in the coats under these conditions are ascribed to oxidation processes (Benedict and Robinson 1946) or to dehydration of the coat colloids (Crocker 1916).

Fires remove impermeability from seeds of *Rhus ovata* (Stone and Juhren 1951), but their value as a common means of causing permeability has not yet been assessed, although it has been estimated as being of limited importance (Went, Juhren and Juhren 1952).

Passage of the seeds through the bovine digestive tract may also cause impermeable seeds to become permeable (Muller 1934, Burton 1948).

The importance of causing prompt germination in agricultural practice has promoted investigation into methods of artificially causing permeability (literature amply summarized in Jones 1928, Spaeth 1934, Barton and Crocker 1948, Crocker 1948, Porter 1949, Crocker and Barton 1953, and elsewhere). The most important amongst these methods are:

(1) Mechanical scarification (Rose 1915, Ohga 1923) by means of a file, emery paper, throwing against banks of needles, etc.

(2) High hydrostatic pressure (P. A. Davis 1928) is sometimes useful.

(3) Boiling or moist storage at high temperatures (Poptzoff 1928, Toda and Isikawa 1951).

(4) Corrosion of the coats with sulphuric acid (Cavazza 1953a).

(5) Impaction by shaking in a bottle (Hamly 1932, Porter 1935), thereby dislodging a suberin plug from the strophiolar cleft (in Leguminosae, Hamly 1932).

(6) Presoaking the seeds in absolute ethanol, thereby permitting water to moisten the walls of the minute openings in the numerous lacunae in the seed coat (in Leguminosae, Verschaffelt 1912, Shaw 1929).

(7) Dry heat has been found as useful as acid corrosion for seeds of *Paspalum notatum* (Hodgson 1949), and probably acts in such a manner in *Malva* species (Ruge and Liedtke 1951).

Impermeable coats enclosing the embryo occur widely amongst the Malvaceae, Geraniaceae, Chenopodiaceae, Convolvulaceae, Solanaceae and others (Crocker 1948), but in the Leguminosae they constitute a prevalent germination regulating mechanism (Harrington 1916).

In the Leguminosae impermeable seeds of the various sub-families react differently to different permeability treatments. While Papilionaceae react to impaction and not to ethanol, the Caesalpiniaceae do the opposite, and the Mimosaceae occupy an intermediate position. These different reactions fit in well with the construction of the seed coat (Barton 1947).

The structure and composition of these coats have been widely investigated (Martin 1922, Jones 1928, Shaw 1929, Spaeth 1934, Stone and Juhren 1951) and summarized (e.g. Porter 1949).

(c) Coats with mechanical resistance. These are completely permeable to both water and gases, and only hinder germination through mechanical resistance to the expansion of the growing embryo. They have been described in seeds of *Alisma plantago* (Crocker and Davis 1914) and *Amaranthus retroflexus* (Crocker 1916), and in the endocarp of *Rubus idaeus* (R. C. Rose 1919), peach and cherry (Haut 1938).

(d) Coats with selective permeability. Coats with such properties are known in *Xanthium* seeds (Shull 1913), where it was shown that this property does not reside in any live part of the coat, but in the two inert inner layers of the coat. Selective permeability is a common occurrence in various families (Van der Marel 1919). As has been mentioned before, the inner seed coat in *Cucurbita pepo* shows selective permeability to gases (Brown 1940).

Although a great deal is known about the properties of these membranes, there is still no suggestion as to the function of the substances kept within the membranes, or excluded by them.

(e) Miscellaneous. In this category are grouped all cases where the softening or the removal of a structure enclosing the embryo was found to further germination, but no precise information has been given as to the nature of the inhibition removed in this manner.

Germination of avocado (Eggers 1942), cucumber (Watts 1938) and tung (Sharpe and Merrill 1942) seeds is stimulated by removal of the seed coat. In non-stratified

peach seeds only a limited section of the coat, that immediately covering the micropyle, is responsible for inhibition, since its removal is sufficient and essential for germination, but the nature of this inhibition is unknown (Tukey and Carlson 1953). The opposite situation exists in grape seeds, the germination of which is inhibited by removal of a small section of the coat above the radicle (Flemion 1937a).

Many grass seeds germinate better after sulphuric acid treatment (Hiltner 1910), but the nature of the inhibition which is removed is unknown, particularly as the seeds take up water even without this treatment (V. K. Toole 1941).

A special coat effect is known in seeds of *Typha latifolia*, where removal of the seed coats does away with the beneficial effects of reduced oxygen supply on germination (Morinaga 1926c).

Exogenous chemical effects

A large list of chemicals which inhibit germination is known (e.g. Barton 1940c), but, as the process of germination in nature is affected only by the naturally occurring ones, as listed by Evenari (1949), we shall confine ourselves to those.

A great deal of work in this field has been carried out at the Hebrew University of Jerusalem (Konis 1938, 1940, 1947, Mosheov 1937, Evenari 1940, Sroelov 1940, Ullmann 1940, Vahl 1940, Yardeni 1948, Evenari and Evenari 1951), and has been reviewed in several papers (Evenari 1940, 1949, Evenari et al. 1942, Duym et al. 1947). We shall, therefore, be content with a short resumé of these summaries, and a review of several recent papers dealing with this subject.

(a) The naturally occurring germination inhibitors are of great biological importance in the life of the plant. First, they inhibit premature germination of seeds in unripe fruits and in fleshy fruits (e.g. Oppenheimer 1922). Secondly, they manage to scatter germination in such cases where part of the fruit is indehiscent and contains inhibitors (e.g. *Sinapis*). Thirdly, they play a major part in the sociological relationships of plants, by diffusing from various plant organs into the soi and preventing germination in their neighbourhood, thereby ridding the plant from a great deal of undesired competition (Froeschel and Funke 1939, Ullman 1940, Went 1942, Bonner 1949, 1950, Went et al. 1952). There seems to be some doubt as to the true value of the inhibitors in this respect (Borris 1936, Ullman 1940, Evenari and Evenari 1951, King 1952), on the grounds that the soil is a universal adsorbent and would minimize the effects of these inhibitors. However, naturally occurring inhibitors are known to inhibit germination of various chapparal plants in the field (Went et al. 1952).

(b) It is as yet unknown whether these inhibitors inhibit germination specifically, or whether they merely inhibit some early phase of growth.

(c) These inhibitors are of widespread occurrence, and are not confined to specific plant organs, or to certain systematic groups.

(d) The inhibitors are non-specific, but there may be varying degrees of susceptibility to the same inhibitor in seeds of different species.

(e) The osmotic pressure and the *p*H of the inhibiting sap or extract play only a secondary role in the inhibition in the great majority of cases (especially wherever the inhibitor proved to be volatile).

(f) The inhibitors which have so far been isolated, and the structure of which has been elucidated, belong to certain more or less well-defined groups of chemical substances.

(g) Very low concentrations of the inhibitors often cause promotion of germination. In this they are very similar to growth substances of relatively high concentration which cause growth inhibition. During the process of germination inhibition may disappear or be transformed to stimulation through correlative action of the different parts of the seed (Eckerson 1913, Cox 1942, Luckwill 1952).

(h) Most germination inhibitors are also strong growth inhibitors. This seems to indicate that inhibition of germination is no more than inhibition of early phases of growth. On the other hand, it is known that various growth regulators are completely ineffective in germination (Barton 1940a, b, Youden 1940, Justice 1941). This may result from the impermeability of the seed coat towards them. A solution of this problem would very much advance our knowledge regarding the degree of identity between growth and germination inhibitors.

(i) Several cases of correlation between the effect of light and that of inhibitors on germination are known to exist. In general the inhibitors tend to increase the inhibiting effects of light or dark, but are relatively ineffective under optimal conditions of illuminations. In some light-insensitive seeds the presence of inhibitors causes light inhibition (Mosheov 1937, Duym et al. 1947).

Seeds of *Apium graveolens* (Taylor 1949) contain an inhibitor which retards their germination, and causes their infection by fungal growth in the germinator. This effect can be countered by pretreating the seeds with oxidizing sterilizing agents (e.g. NaOBr). Similar effects of NaBr on other seeds are also known (Wallwitz and Wallwitz 1926). A rapid entry of water into seeds of "sensitive" strains of cotton (which was managed by a vigorous shaking in water, followed by blotting off of excess water) prevented attack by micro-organisms (Toole and Drummond 1924) and permitted an uninhibited germination in a germinator. On the other hand, the same untreated seeds germinated perfectly well in soil. In this case, as well as in the above-mentioned cases, the presence of inhibitors is indicated, without the possibility of telling whether the inhibition of germination is the cause or the result of the fungal attack. It is not, therefore, clear whether the washing and pretreatment remove the fungal spores or the inhibitors.

Experiments with seeds of *Picea excelsa* (Bautz 1953) have demonstrated that soil may have active effects on germination, besides its passive action as a general adsorbent of inhibitors. Germination of these seeds, which do not contain inhibitors, is hastened by dilute extracts from unburnt soils, or by the soils themselves, while it is inhibited by concentrated extracts.

Went (1949) and Soriano (1953) have demonstrated a new aspect of the effects of inhibitors on the biology of desert plants. Such seeds (according to E. H. Toole 1936)

are known to remain "dormant" until an amount of rainfall sufficient to maintain growth has fallen. The results of Went's and Soriano's experiments prove that this is managed by means of inhibitors, because seeds responded better to sub-soil irrigation which was preceded by rain, than to sub-soil irrigation alone. The phenomenon of an optimal rainfall above which germination is reduced may also be a result of an increasing dilution of the inhibitor until it starts promoting, then an increasing dilution of the stimulating influence. A still unexplained phenomenon is that of the lower germination after an interrupted rainfall, as compared with the results of a similar, but uninterrupted rainfall.

The physiological significance of semi-permeable membranes around the embryo may be elucidated in case it turns out that they serve to exclude from the embryo inhibitors which ordinarily occur in its neighbourhood.

Illumination

Responses of germination to conditions of illumination during germination are varied, and range from light inhibition, through light indifference, to light stimulation (cf. Kinzel 1913). Ecologically, the two former types are more comprehensible, because such seeds may, or are obliged to, germinate inside the soil, whereas seeds belonging to the latter category can only germinate on the soil surface, where chances of seedling establishment are small, as a result of the more extreme ecological conditions. However, in moist habitats, light stimulation might provide the advantage of preventing germination in excessive shade, while in seeds of water plants, like *Scirpus* (Isely 1944) or *Eichhornia crassipes* (Barton and Hotchkiss 1951), it might limit germination to shallow water. Light stimulation may also prove advantageous to seeds low in storage materials, where the seedling would have to start photosynthesizing as soon as possible.

According to the review by W. Stiles (1950), taxonomic relationship does not necessarily entail a similarity in the response of germination to light, but sometimes a certain type of response is of widespread occurrence in a genus, or even a family.

The light factor rarely acts by itself, and usually interacts with one or more other factors. Thus, for example, light sensitivity of lettuce seeds is conditioned by moisture conditions preceding germination (Evenari and Neumann 1953b). A diminishing response to illumination during the ageing of freshly harvested seeds is a common phenomenon (Gordon 1951). In a great many cases a marked interaction is found between temperature- and light-requirements in germination (e.g. Kadman 1954). These interactions in light-stimulated seeds have been classified (W. Stiles 1950) as follows:

(a) Germination stimulated by a light-low temperature combination; dark-germination occurs only at high constant temperatures, or at a daily alternation (e.g. *Epilobium hirsutum*, *Veronica longifolia*).

(b) Germination stimulated by a light-low temperature combination; dark-germination obtainable only by daily alternating temperatures; e.g. *Poa pratensis* (W. Stiles 1950), *Rumex crispus* (Gardner 1921), *Apium graveolens* (Morinaga 1926b, Taylor 1949),

and *Oryzopsis miliacea* (Koller and Negbi, in preparation). In the last named case it was found that even a single thermo-period was sufficient to give the full effect.

(c) Germination stimulated by a combination of light, and low or daily alternating temperatures; dark-germination unobtainable by either high or daily alternating temperatures (e.g. Gesneriaceae).

(d) Germination requires daily alternating temperatures, and is then light-stimulated; the light effect can be separated from the temperature treatment by drying the seeds after illumination (e.g. *Ranunculus sceleratus*).

(e) Germination light-stimulated at high temperatures, light-indifferent at intermediate temperatures, and light-inhibited at low temperatures; e.g. *Chloris ciliata* (according to Gassner), *Amaranthus retroflexus* (Axentjev 1930), *A. lividus* (Kadman 1954), and *A. caudatus* (Kadman, personal communication).

Light stimulation which decreases with rising temperatures is known in freshly harvested lettuce seeds (Thompson 1938). In lettuce seeds (var. Grand Rapids) there exists a low temperature at which germination is high, and a high temperature at which germination is very low. At both these temperatures light has no effect on germination, but at an intermediate temperature it greatly stimulates germination. This points out two separate mechanisms regulating stimulation, one of which is light-insensitive and operates up to the lowest temperature, below which light has no effect, the other being light-sensitive, and operating up to the highest temperature above which light has no effect (Evenari et al. 1953).

As has been indicated above, light and temperature effects can, in some cases, be given separately, and the seeds may also be dried between the light treatment and the temperature treatment without impairing germination (Kincaid 1935, Thompson 1938).

Light-inhibited seeds have been investigated to a lesser extent with regard to light/temperature interrelationships. According to Lehmann (1912), light inhibition may be reduced by low germination temperatures. This was verified for several light-inhibitep desert plants (Koller 1954).

Working with lettuce seeds, Weintraub (1948) concludes that light is necessary for germination only under unfavourable germination conditions, such as at supra-optimal temperatures, or in the presence of inhibitors. This brings us to the interaction between light and inhibitors. Light-stimulated lettuce seeds gradually lose their sensitivity towards light with age, but regain it under the influence of the inhibitor coumarin (Evenari 1949). The opposite is true for light-inhibited seeds (Duym et al. 1947), where inhibitors extracted from beet seed-balls had a more pronounced effect in the light than in the dark. In apparently light-insensitive seeds (Mosheov 1937) the inhibitors from wheat also caused a greater inhibition in the light than in the dark. A direct relationship between light and inhibitors is known for *Phacelia tenacitifolia* (Magnus 1920), where light stimulation could be entirely replaced by washing the seeds. A special interaction exists between the action of light and that of potassium nitrate in germination. In many cases nitrates stimulate dark-germination of light-stimulated seeds, although not to the same degree as does light (V. K. Toole 1938, 1941, Toole and Toole 1941). The fact that nitrates stimulate also the light germination

of such seeds tends to show that, although light and nitrates work in the same direction, they apparently take different pathways.

Several instances are known of interrelationship between the action of light in germination, and the presence or absence of coats enclosing the embryo. Thus the inner seed coat of *Citrullus colocynthis* causes complete inhibition in light at 26°C, but has no effect in darkness, or at 30° and 35°C (Koller 1954). Similarly, dark-inhibited seeds of *Rumex crispus* may be made to germinate in the dark by removal of the seed coat (Axentjev 1930). Inasmuch as increasing the concentration of oxygen achieves the same end, the true interrelationship appears to be between light and oxygen supply. A similar case is known in *Phacelia tanacetifolia*, where removal of a small portion of the seed coat in the chalazal or micropylar regions removes inhibition both by light and by high temperatures (Boehmer 1928). Here, too, a close dependence on oxygen is evident because increased oxygen reduces light inhibition in intact seeds, and covering the wounded coats with moist filter paper re-establishes light inhibition. Axentjev (1930) states that in four out of six light-inhibited species, and in two out of four light-stimulated ones, the action of light depended entirely on the intactness of the seed coat. Inasmuch as in these cases the need for removal of the coat could be obviated by increased oxygen pressure, it was concluded that, while coat action was merely withholding of oxygen, that of light was the inhibition or stimulation (according to type) of oxygen-requiring processes in the embryo. This fits in rather well with the results of Evenari and Neumann (1952), who found that the need for light in lettuce seed germinating at high temperatures could be obviated by wounding the endosperm, and of Borthwick and Robbins (1928), who found that a thin cuticular membrane enclosing the endosperm prevents the exit of carbon dioxide from the embryo at high temperatures. Other instances of interaction between light- and gas-effects are mentioned in the section on gases.

The light quantities which are effective in the germination of light-sensitive seeds vary greatly. Some seeds, e.g. those of tobacco (Kincaid 1935) or those of *Lythrum salicaria* (Lehmann 1918), are sensitive to very low amounts. Seeds of *Agrostis* germinate to a greater extent under higher light intensities (Legatt 1946). Some seeds, e.g. those of *Amaranthus blitoides*, are stimulated to a greater extent by small quantities of light than by continuous illumination (Kadman 1954). In dark-inhibited lettuce seeds, a few seconds of illumination suffice to allow dark germination (Evenari and Neumann 1953a). This sensitivity commences within a few minutes after imbibition has started, and reaches its peak within eight hours for white light, and within three hours for red light. A case is also known where the action of a short illumination is diametrically opposite to that of a continuous one: seeds of *Atriplex dimorphostegia*, which are completely light-inhibited at 26°C, are stimulated by a short illumination over and above the dark controls (Koller 1955). On the other hand, light requirements for the germination of *Mimulus ringens* are much higher, as it requires at least one hour's low intensity illumination daily, or three to four days' constant illumination (Hutchins 1932).

A special aspect of light effects on germination has not received its due amount of attention. Jensen (1941) found that in seeds that had been illuminated in the dry

condition by Quartz and Sollux lamps, and then stored in well stoppered glass jars, high seed viability could be maintained longer than in untreated controls. Since most of the species that respond to this treatment are not known to be light-sensitive, a rather special mechanism seems to operate here. Storage conditions also effect light sensitivity in lettuce (Evenari and Neumann 1952).

A great deal of controversy still exists regarding the mode of light action in germination, but its discussion is not attempted here, as it lies outside the scope of this paper. However, if the great differences between light responses and requirements in different species are considered, it would not appear unlikely that there are several different mechanisms of light action.

DISPERSAL UNITS

It has been shown that, though germination itself is a function of the embryo, the structures enclosing the embryo may exert a far-reaching influence in regulating its germination. These structures, which regulate gas- or moisture-exchange, oppose the expansion of the embryo, influence its light requirements, or contain germination inhibitors, may be made up of morphologically different plant organs, from nucellar membranes and endosperm to receptacle and neighbouring sterile florets.

Biologically and ecologically, as long as these structures accompany the embryo at the time of seed dispersal, they are important to the process of germination. Consequently, to the extent that the embryo is dispersed in nature with any kind of tissue adhering to it which may or may not influence its germination, such a tissue cannot be ignored even though it may not be part of the seed proper.

With this consideration in mind the testing of germination should always start with the dispersal unit, and great care should be taken to speak of the germination of the seed only in those cases where the dispersal unit is made up of the seed only, in the strict botanical sense.

"DORMANCY"

The term "dormancy" has been variously defined and used by different workers, and to this day a great deal of controversy exists as regards this nomenclature. Even the broadest definition of a "dormant seed" as one which does not germinate under normal external conditions, leaves much to be desired, because of the extreme variety exhibited by the external conditions which are optimal for the germination of various species.

Strictly speaking, only one component of any seed actually performs the act of germination. That component is the embryo. All other parts of the dispersal unit which accompany and enclose the embryo serve only in the capacity of co-factors in this process of germination, by protecting the embryo, by supplying nutrients, or by otherwise regulating the process of germination.

Germination of the embryo itself is controlled by relatively few basic factors, most of which are effective in various other growth phenomena. Some of these factors are (a) hydration of protoplasm, (b) the presence of digestible food, (c) a sufficiently high oxygen concentration for the maintenance of energy supply via aerobic respiration, (d) an efficient waste-disposal system for the elimination of toxic or narcotic metabolic by-products, (e) temperature at an optimal level for the coordinated functioning of the various biochemical systems, (f) light, for the operation of essential photo-chemical processes; or dark, for the prevention of photo-inactivation of essential processes or substances.

All the factors enumerated above have to pass through each and every structure which encloses the embryo, and this way may be extremely long or tortuous, biologically speaking. Along this way, the factors may be modified, delayed, or even entirely prevented from reaching the embryo. They may also have a specific action on some of the enclosing structures, and thereby produce secondary effects on the behaviour of the embryo, or evoke a change in the germinative response of the dispersal unit as a whole.

Since only the embryo performs the actual act of germination, the criterion for "dormancy", or for a lack of the ability to germinate not resulting from permanent loss of viability or from an incomplete embryo, should be applied to the embryo alone. In other words, a state of "dormancy" could be proved to exist only where a viable embryo failed to germinate despite being subjected to the action of all possible combinations of factors which are known to operate in germination (and in other growth phenomena).

The state of affairs, as presented in this review, leads to the conclusion that "dormancy", as defined, is a non-existent state, and that the only difference between "dormant" and "non-dormant" embryos lies in the degree of specificity of conditions which the embryos require for germination. The same considerations apply not only to embryos, but to intact dispersal units, with the difference that, owing to the intervention of the various structures enclosing the embryos, this degree of specificity may be extremely modified and enhanced. This is most striking in dispersal units with structures which greatly restrict, or even entirely prevent, access of one or more of the essential factors to the embryo. It is well known that in such cases the structures eventually cease to constitute an obstruction, and that the rate at which this change proceeds is affected by some of the very factors which affect germination, though in different ways.

It is also becoming more apparent that, with the exception of the last named type of dispersal unit, where access of essential factors to the embryo is postponed, units of all species will germinate if acted upon by the succession of ecological events which normally occur in their natural habitat between fertilization and the season of germination.

Some confusion has also arisen out of the frequent neglect of one important factor in theoretical considerations of germination and "dormancy". That factor is "time". Germination is a complex, little understood, process which is known to involve processes of imbibition, activation of enzymatic and hormonal systems, energy build-up,

and, finally, growth (cell division and cell elongation). Each one of these, by itself, is a time-requiring process. The combined effects of these processes sometimes may require even more time. In analogy with birth processes in mammals this period may be termed the "parturition period", though the processes taking place are entirely different in the two cases. The extreme variations in the duration of this parturition period in various species, even under optimal conditions, is sufficient to obscure its existence. What causes even more confusion is the fact that in a great number of cases the overall process of germination requires not a constant set of factors, but rather an orderly, pre-determined, sequence of changes in the intensity of several factors, acting during parturition. These changes often manifest themselves as periodically fluctuating factors, similar to those in other phases of developmental physiology (cf. for example Went, in Murneek and Whyte 1948, and Went 1953).

Once it is accepted that time is also a factor in germination, and that the action of some of the other factors is sometimes strongly correlated with this "time factor", it is possible entirely to discard "dormancy" as a superfluous term, and to realize that the various mechanisms of dormancy are no more than ways and means which cooperate to ensure the survival of the species by regulating germination, and confining it to the suitable habitat and season.

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INOCULATION EXPERIMENTS WITH *PESTALOTIA VERSICOLOR* SPEG.

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ABSTRACT

Fourteen common garden plants in Israel were inoculated with *Pestalotia versicolor*, which was isolated from the air, in order to see on which of them it might develop. Positive results were received on the four following plants: *Acacia cyanophylla* Lindl., *Dodonaea viscosa* L., *Euonymus japonicus* L. and *Schinus molle* L. *Acacia cyanophylla* was found to be the most sensitive to our strain of *Pestalotia versicolor*. *Nerium oleander*, upon which *Pestalotia versicolor* was found in Italy, did not receive the infection of our strain.

R. Barkai-Golan isolated from the air in Tel Aviv *Pestalotia versicolor* Speg., as described by Guba (1929).

Pestalotia versicolor was first found on decaying leaves of *Nerium oleander* in Italy by Spegazzini. Klebahn (1913) isolated *Pestalotia versicolor* from *Darlingtonia*, and successfully infected with it a wide range of plants. According to Guba (1929), Klebahn's fungus does not correspond in all details to *P. versicolor* found on *Nerium*.

As our fungus was isolated from the air, an attempt was made to determine on which of our common garden plants the fungus would develop.

The fungus was grown in Petri dishes on potato dextrose agar at room temperature. 24 hours after the inoculation, an aerial mycelium could be seen. After 3 days the diameter of the colony reached 4 cm, the acervuli appearing crowded in the centre, and after eight days the colony occupied the entire surface of the Petri dish. A suspension of the spores in sterile saline was used for the inoculation of the following trees and shrubs:

Acacia cyanophylla Lindl.
Ceratonia siliqua L.
Cercis siliquastrum L.
Dodonaea viscosa L.
Euonymus japonicus L.
Ficus elastica Roxb.
Laurus nobilis L.
Ligustrum ovalifolium Hassk.
Nerium oleander L.
Pittosporum tobira Ait.
Pittosporum undulatum Vent.
Populus alba L.
Populus nigra L.
Schinus molle L.

Healthy branches bearing leaves were washed in water and alcohol, placed in Erlenmeyer flasks containing water, and kept in a sterile chamber at 26°—29°C. In each plant 4 leaves were infected as follows:

(a) without injury: leaf 1 on upper side, leaf 2 on lower side;
(b) after causing injury: leaf 3 on upper side, leaf 4 on lower side.

Each leaf was infected in three places, where a drop of the spore-suspension was placed, and covered with a piece of sterile cotton wool imbibed with the suspension. The experiment lasted from 7.VIII to 3.IX.1954 and the progress of the disease was observed every two days, when the cuts at the ends of the branches were renewed and the water in the Erlenmayers was changed. The plants kept well and even grew during the experiment.

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RESULTS

At the end of the experiment only five species out of fourteen and only their injured leaves became contaminated: *Acacia cyanophylla*, *Dodonaea viscosa*, *Euonymus japonicus*, *Populus nigra*, *Schinus molle*.

In *Acacia cyanophylla* the leaves wounded on both sides were contaminated, in *Dodonaea viscosa* and *Euonymus japonicus* only on the upper side, and in *Populus nigra* and *Schinus molle* only on the lower side.

Around the infection points of these five plants light brown zones of dead tissue were formed, on which black acervuli appeared. In *Dodonaea viscosa* acervuli were also formed along the midrib of the leaf. The disease developed more rapidly in *Acacia*, where acervuli appeared six days after the inoculation. At the end of the experiment the dead tissue zone containing many acervuli reached 15 mm. It was surrounded by a pale zone which contained the hyphae of the fungus. The leaf became pale, crumpled and dry (Figure 1).

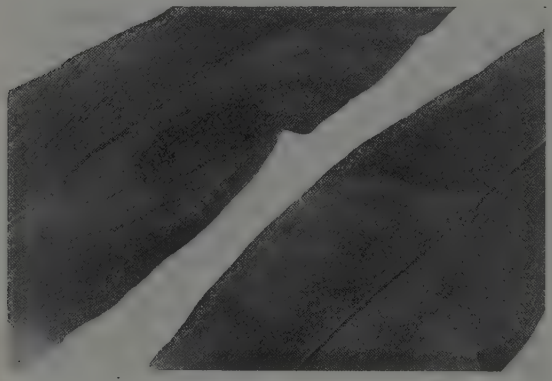

Figure 1
Leaves of *Acacia cyanophylla* Lindl. infected with *Pestalotia versicolor* Speg. (enlarged)

In the other 4 plants development of the disease was slower, acervuli began to appear 10—14 days after the inoculation, the diameter of the dead tissue zone was only 3—5 mm, and the leaves remained almost unchanged.

Thus, according to our results *Acacia cyanophylla* is the most sensitive to our strain of *Pestalotia versicolor*. *Nerium oleander*, upon which *Pestalotia versicolor* was found in Italy, did not receive the infection of our strain.

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NEWS AND VIEWS

International Arid Lands Meeting

April 26 — March 4, 1955, Albuquerque and Socorro, New Mexico, U.S.A.

An international Arid Lands Meeting took place between April 26 and May 4, 1955 in Albuquerque and Socorro, New Mexico. The suggestion for holding this meeting came from Peter Duisberg, Chairman of the Committee on Desert and Arid Zone Research of the Southwestern and Rocky Mountain Division of the American Association for the Advancement of Science. Dr. Duisberg, who was very enthusiastic about the Symposium on Desert Research held in Jerusalem in 1952, thought that such symposia should be held at regular intervals in different parts of the world where the arid zone problem exists. Since, in his opinion, the problem of arid zones does not get enough consideration in the United States, he suggested to the National Board of the A.A.A.S. that the next meeting be held in a U.S. arid zone. The suggestion was approved and the UNESCO Advisory Committee on Arid Zone Research agreed to cooperate and to schedule its own meeting at about the same time and place, in Tucson and Socorro. The meeting itself was supported by the National Science Foundation and the Rockefeller Foundation, in addition to the three organizations already mentioned. The host institutions were the University of New Mexico in Albuquerque and the New Mexico Institute of Mining and Technology in Socorro.

The International Arid Lands Meeting was the best organized international meeting I have ever attended, both from the technical and organizational aspects. The programme was divided into three parts, consisting of 3 days of lectures in Albuquerque, a two-day field trip where the Rio Grande project was shown as a sample of what could be done with grand scale irrigation, and a 3-day conference in Socorro. The aim of the meeting was "to bring together people from various sciences who could pool ideas and efforts to help solve scientific and developmental problems of arid zones, and to explore theoretical scientific advances and their application to specific problems". It was specifically pointed out that the meeting was not held in order to give people opportunity to discuss past research but mainly to discuss the possibilities of development of arid zones, based on past experience. The conference in Socorro, to which only a carefully selected group of experts was invited, had a special goal. Here, during free discussions, experts exchanged views and ideas to work out ways for the various sciences to cooperate in solving arid land problems, with the hope that specific recommendations would result from the deliberations.

The Symposium opened on April 26 with an evening lecture by Homer L. Shantz on the history of arid zone development and the problems and potentialities of arid land. Dr. Shantz, who is in his 80th year, is the famous plant physiologist who many years ago wrote, together with Briggs, the basic research works on the water requirements of plants. During the symposium and conference Dr. Shantz continually astonished us with his enormous knowledge, his keen mind and his undiminished enthusiasm for anything concerned with water requirements of plants and arid zone research in general.

The first session on April 27 dealt with the following questions: To what extent is precipitation in an arid region predictable? Are there any distinct drought cycles? What are the prospects of occurrence in arid areas of usable ground water? What is the practicability of locating and estimating volume and rate of natural recharge of underground water supplies? Within a given watershed, to what degree can the water sources and water yields be determined?

During this session Jean Tixeront stated that in Tunis cleaned out wells produced the same amount of water as in old times, thus

proving that Tunis of today is not more arid than it was in Roman times. Terah L. Smiley, a geochronologist, found in studying tree rings that there are pronounced cycles of dry years occurring at irregular intervals and, therefore, unpredictable.

The following questions were raised in the afternoon session, which was devoted to a discussion of the better use of present resources in arid zones: How can production from grass and forest lands be increased and maintained without accelerating erosion? What are the consequences of utilizing arid lands beyond their capabilities? What constitutes wise allocation of water among the various needs in arid land drainage areas? How can production be increased with existing water supplies? Can irrigated lands be occupied permanently? Here, R. O. White of the FAO gave a very interesting survey on the re-establishment and creation of pasture land, especially in the Middle East. Hilgard O'Reilly Sternberg from Brazil brought out the very interesting fact that even an area receiving annually 600 mm precipitation can be converted into a desert by bad management.

Pedro Armillas, an archaeologist from Mexico, stressed the importance of archaeological research of agricultural methods in arid lands, and proved that this research has practical implications for today. The stimulating evening lecture by Charles E. Kellogg on "The role of science in man's struggle on arid lands" stressed the point that scientific progress concerning arid lands has advanced more in some fields than in others. Economic and legal research, for instance, is less advanced than research in natural sciences. The great potentialities of plant breeding based upon more fundamental research in modern genetics and plant physiology have not been fully used for arid lands. A large percentage of water delivered to irrigated land is still wasted by some farmers who could get "certainly twice as much" of the amount of water used by applying available scientific knowledge.

The morning session of April 28 was devoted to the questions of how practicable it is to induce precipitation, to demineralize water, to re-use waste waters, and what are the social and economic implications of these programmes. First we heard an outstanding lecture by Edward C. Bowen, of Australia, who studied hundred year records of rainfall in certain areas and found that there are peaks on certain dates, for example in January and February. He connects these peaks with the fact that every year on these days the earth passes through meteoric dust which precipitates rain, like artificial cloud seeding. The practicability of inducing artificial precipitation by different methods of cloud seeding was then discussed but no clear picture was given. The claims of success are too vague, as there is no sound scientific method of evaluating the results. A very interesting lecture on the feasibility of desalting water was given by Louis Koenig, an economist, who stated that today the desalting of brackish water is economically feasible only when water costs or supply are marginal. Dr. Koenig pointed out that one acre/foot of water used in industry will support about 60 times as many workers as when used in agriculture in arid lands. "From the standpoint of water use, agriculture is a marginal use of water", the conclusion being that one should produce food in humid regions and develop industry in arid lands.

During the meeting interesting information on the cost of desalting sea water was brought out. Using vapour compression distillation, one acre/foot of water costs about $ 375; using solar distillation the price is $ 325, whereas the economic maximal price would be $ 125 for municipal water and $ 40 for irrigation water.

In the afternoon session, which dealt with the better adaptation of plants and animals to arid conditions, the main questions discussed were: What screening procedures would lead to the selection of more productive plant and animal species for arid regions? What are the genetic and physiological bases for drought resistance in plants and animals? What are the prospects of increasing drought resistance through genetic research? How can we develop a programme of revegetation? What are the economic possibilities in the development and utilization of arid lands, plants and animals? What are the possibilities of maintaining larger human populations in arid areas?

Colonel Omar Draz from Egypt and R. Merton Love from California lectured on new methods for selecting drought resistant animals and plants in desert and semi-desert areas.

Knut Schmidt-Nielson from North Carolina reported on the physiological adaptation of desert animals to lack of water. Certain desert animals can live on dry plant food without having a single drop of water, and others can drink and exist on pure sea water. To cut down evaporation, the camel can increase its normal body

temperature by several degrees centigrade; it does not lose its appetite even under prolonged drought; urea in its urine is re-used in protein synthesis. These facts show that much more important practical information can be gained by physiological research on desert animals.

Uvarov from the Anti-Locust Research Centre in London emphasized the danger connected with the creation of pasture land in desert areas — cultivated spots in a mosaic pattern increase the danger of locust invasion. At the same session I gave my own lecture on Desert Agriculture in Israel.

The next day, April 29, was devoted to informal discussion meetings, held in 14 different groups. Each symposium participant was free to choose a group and I attended groups discussing the possibilities of improving desert plants and animals and their utilization in arid areas. I have never attended any scientific discussion which was so stimulating, free, and informal and gave so much opportunity for thought and exchange of opinion as this discussion group in Albuquerque.

The next morning, on the 2-day field trip, we stopped at Gran Quivira National Monument, where a large flourishing Indian village existed in 1627 when a Franciscan Missionary established a church. Near the end of the 17th century the Indians and Franciscans were forced to abandon the village because of severe Apache raids. Since then Gran Quivira slowly crumbled into ruins. We inspected the ruins and the traces of old Indian agriculture which was based on collecting water from arroyos — what we call wadis — and spreading it over the fields by a method very similar to that employed by the Nabataeans in the Negev.

Toulouse states in his paper (Early water systems at Gran Quivira National Monument): "Examination reveals that the ditches, reservoirs and terraces surrounding the ruins all serve to extend the difference between extinction and survival". This illustrates that in all desert areas of the world people throughout the ages have used the same system of agriculture — water collecting and spreading — in order to survive.

The following day we visited the huge Stahman farm, irrigated by the waters of the Rio Grande. It has extremely large pecan orchards and a complete pecan processing factory. A quarter of a million geese, whose fine feathers are economically the most valuable product of the farm, are also raised.

Next we visited the New Mexico State College Experimental Ranch, where reseeding experiments have been carried out for 20 years.

The report we received about the farm states: "results of these planting trials indicate that reseeding this type of range land is a risky undertaking at best and indicates the needs for range management that will preserve the native range in good conditions". In visiting the farm I was impressed by the fact that no attempt was made to collect rainwater for use in a system of water spreading.

Then we stopped at the Big Elephant Butte Dam, where water of the Rio Grande is stored to irrigate 159,000 acres of land with 608 miles of canals and 459 miles of open gravity type drains. Since the irrigation scheme of the Rio Grande project started in 1915, the crops produced by it have reached a total value of 679.5 million dollars. During the years the project has encountered some difficulties, such as the silting of the reservoir of the Elephant Butte Dam, which has considerably reduced the storage capacity. In addition, it flattened the grade of the river above the lake and transformed fertile irrigated farm lands into an extensive swamp now called San Marcial Swamps. Here, thousands of acres were invaded by the salt cedar, *Tamarix gallica*, a Mediterranean plant introduced into the U.S. between 1899 and 1915. In 1951 the U.S. Bureau of Reclamation started a project to prevent or reduce the loss of water in these swamps by constructing channels and spraying the salt cedar with herbicidal hormones from airplanes. I have never seen elsewhere a plant control scheme of this size. It was not, however, a complete success — the mature salt cedars were wiped out, but the apparently dead trees began to sprout at their bases.

On the evening of the same day we arrived in Socorro, where we were the guests of the New Mexico Institute of Mining and Technology.

On the morning of May 2, the conference started in very congenial surroundings and all delegates sat around an imaginary centre, facing each other. The success of this conference was largely due to the very able chairmanship of Gilbert F. White, President of Haverford College, who was ably assisted by John A. Behnke, administrative secretary of the A.A.A.S. In the general discussion in which all members of the conference participitated the main points brought out were:

(1) A great gap exists between scientific knowledge and its application to arid land development

(2) We do not possess enough facts on the economic aspect of arid land development. (3) There seems to be an overemphasis on valley irrigation; not enough attention is paid to the developments of arid lands by using, as one of the participants said, "water where it falls". (4) There is a need for an integrated pilot survey of a carefully chosen area to teach how future surveys should be made. (5) We do not fully avail ourselves of the knowledge gathered by old cultures and civilizations and by primitive people of today who practise agriculture in arid zones. Interesting examples were given of Curaçao, where dam cisterns in arroyos are built, water sinks into ploughed ground and is stored until it is used locally again by pumping it up. A similar method is used in Kenya. (6) Attempts to modify weather by cloud seeding processes, etc., do not permit a scientific evaluation of the results. (7) Not enough attention is given to the importance of microclimate in the life of desert plants and animals, and such data should be collected by utilizing the distribution of plant species in communities, as indicators. (8) It was generally recognized that dew is an important factor in the life of desert plants and has practical value. (9) More attention should be paid to the selection and breeding of drought resistant ecotypes of plants and animals. (10) We do not know enough about the ecology of desert plants to enable us to determine how these species make the most effective use of their natural environment. (11) Although we possess considerable knowledge about groundwater in arid zones, more research on the groundwater problem is needed. There was a long discussion, started by myself, on the need for an international centre for desert research. The question was left open.

The next day, May 3, the conference split into 3 discussion groups, each dealing with one of the following problems: (1) new approaches in meteorology and applied climatology; (2) concept of the water budget and its areal application; (3) closing the gap between scientific knowledge and its application to arid land development.

May 4, the last day of the conference, the conference met in plenum and summed up the recommendations of the three groups. I would like to give here some of the main recommendations:

Anthropology and Archaeology

1. A bibliography of our present knowledge of biological adaptations of man and of the cultural patterns in arid climates, past and present, is needed to promote specific research in these areas.

2. Further research is needed concerning the history of land use in arid and semi-arid regions. The UNESCO Advisory Committee on Arid Zone Research is urged to consider means to further this research and to publish a volume on agriculture of the past in the arid and semi-arid lands of the world.

3. Exploration is needed of possible new patterns for resource use and practice, with local participitation in the studies to insure the public understanding so necessary for achieving any change, even on a gradual basis. There is a tendency to encourage the maintenance of existing patterns even when it is realized that existing patterns have been inherited from conditions quite different from the present. Land use histories may be valuable in dramatizing climatic hazards; there is need for long-term improvement in management; and even statistical data on climatic change can be effectively and convincingly presented if properly organized.

Meteorology and Climatology

4. The Conference notes with satisfaction the recent decision of the UNESCO committee to devote the next arid lands symposium to climatological problems, and urges sponsorships of continued research of arid land climatology by the Committee.

5. It is recommended that the 1957—58 programme of the International Geophysical Year be extended to include the arid belt of the world and that arid zone countries involved be asked to participate in this programme.

6. More effective climatic studies require more and better equipped meteorological stations at both sea level and higher elevations for surface and upper-air observations in all arid areas.

7. Careful attention should be paid to current research studies concerning relationship of solar emanations and terrestrial weather patterns, with

particular attention to the effects bearing on arid land problems.

8. Synoptic and dynamic climatological studies in arid and semi-arid regions are essential. Emphasis should be placed on interrelationships between the general circulation of the atmosphere at surface and upper levels and precipitation in different areas and times. Such studies may enable the prediction of precipitation.

9. A more vigorous study of all possible aspects of periodic clouding is imperative. Every effort should be made to develop improved techniques for statistical evaluation of weather modification experiments and to use the best techniques and data to analyze the results of such experiments.

10. An international cooperative programme of synoptic observations should be instituted to determine the concentration of ice-forming nuclei throughout the world, especially during periods of the earth's passage through meteoritic streams. These observations should be supplemented by measurements, synoptic if possible, of the concentration of naturally and industrially induced condensation nuclei (including giant hygroscopic nuclei) by studies of the chemical composition of precipitation and by cloud surveys.

11. A more vigorous study of all possible aspects of periodic cloud seeding is imperative.

12. Further studies of nucleation properties of silver iodide as affected by the methods of generation and dispersal are needed, especially with reference to the decay of the nucleating activity of silver iodide as it is exposed in the atmosphere.

13. Closer integration between climatology and hydrology can be fostered through better exchange of information and collaborative analyses to improve joint methodology. The lack of such collaboration has sometimes contributed to inaccurate estimation of water resources in arid-zone projects.

See also recommendations 17, 19, 25 and 29.

Hydrology, Geology and Soils

14. The importance of groundwater in arid zones calls for continued research on the following aspects:

(a) Methods of exploration and estimation of the volume of groundwater bodies.

(b) Methods of increasing groundwater recharge, and of estimating rates of recharge.

(c) The relation of vegetation and other biological factors to groundwater recharge.

(d) The geomorphological aspects of the occurrence and chemistry of groundwater.

15. The precipitation occurring on drainage basins should not be regarded in terms of use for irrigation alone; more consideration should be given to utilization of water which does not reach the points of downstream use.

16. Factors and practices which modify soil structure (grazing, dry land farming, irrigation, etc.) must be studied, keeping in mind the importance of soil structure and its maintenance in relation to permeability and erosion prevention.

17. Hydrologists and climatologists would benefit greatly by extensive vegetation studies, specifically by considering the role of vegetation in the hydrology of dry lands, and plant species and communities as indicators of past and present climates.

18. Further attention should be given to the study of the geomorphic dynamics of landscapes for application to regional and land-type appraisal and land-use planning.

See also recommendations 13, 21, 25, 28 and 30b.

Biology, Ecology and Conservation

19. Intensive studies of the microclimatic environments of plants and animals should be encouraged. The relations between the data normally recorded by meteorological stations and the microclimatic effects of these phenomena in different sections of typical arid environments should be studied intensively.

20. Research on plant and animal ecology improvement and management in arid areas should be intensified with emphasis on the following: preadapted species and races; physiological factors of characteristics desired in breeding; water requirements of the various species and breeds as related to production; the use of

available soil and climatic resources by plants, and the use of available vegetation by various species and breeds of animals.

21. Additional research is needed on methods of determining and estimating water requirements of plants in arid regions, especially the regulation and efficiency of transpiration and its relation to photosynthesis. It is suggested that the UNESCO Advisory Committee compile a review of information and research on this subject.

22. The results of an intensified research should be applied to the management of grazing, a problem of paramount importance in the conservation and improvement of arid grasslands.

23. A thorough investigation should be made of indigenous plants of arid and semi-arid regions to determine their usefulness and adaptability to grazing and cultivation.

24. There is reason to believe that studies of the pharmaceutical and industrial uses of desert plants would be justified.

25. Intensified studies should be made on dew and its potentialities as a supplement to rainfall in arid regions. Such studies should consider the utilization of dew by various plants, the relation of dew to soil moisture, and the establishment of physical relationships for extracting dew from the atmosphere.

26. Adequate areas of natural arid-land ecological communities of indigenous animals and plants in their original habitats are essential for educational and scientific purposes and should be acquired and preserved in the various arid-land countries.

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Arid zone research in Israel

More than half the total area of Israel is arid country. This region, called the Negev*, lies roughly south of the latitude of Beersheba, and is bordered in the West by the Sinai desert and in the East by the 'Araba depression. In the South it extends as far as the Red Sea. The Negev receives an average of no more than 50—100 mm annual precipitation. All rainfall occurs in winter, and is very uncertain as to time of occurrence, total amount, and intensity. These conditions become more extreme towards the south. Soil in the Negev is typical immature desert soil. The only arable soils are loess, sandy loess, and sand. Even these are not abundant in the Negev, and are confined to wadis, depressions, and to the surroundings of Beersheba. Fresh groundwater is also very limited, with various degrees of salinity.

A number of thriving civilized communities existed in the Negev in ancient times (e. g. Nabataean and Byzantine), and left behind them remarkable ruins of cities and well preserved agricultural systems. After the extermination of these communities came centuries of neglect, overgrazing and misuse by desert nomad tribes, so that today the whole Negev is extremely barren, and sparsely populated.

The close proximity of the desert has always promoted scientific interest in it. Lately, large scale immigration into Israel has added a practical aspect to this purely scientific interest. A large number of research bodies, governmental and non-governmental alike, are diverting more and more of their work to applied arid zone research. Valuable contributions have been made by friendly governments and benevolent institutions abroad, by the United Nations, and, last but not least, by the valiant groups of pioneers who have settled in the wilderness, under extremely difficult conditions, with the determination to become the "guinea-pig vanguard" in the conquest of the desert.

The present paper is intended to review solely the typical arid zone problems which are under investigation. It will not touch upon the large volume of work which is being done in connection with the investigation of ores, mineral deposits etc., which applies specifically to the Negev and has no significance for arid zones in general.

A list of the various bodies which cooperate in arid zone research in Israel will be found at the end of this paper.

According to its nature, the work on arid zone research may be classified into surveys, basic research, and applied research. However, surveys and basic research alike have been carried out with the long-range aim of providing the basic data for applied arid zone research. The various surveys which were initiated, and in most cases completed, offer a good example of this.

Most of the area of the Negev was *terra incognita*, as far as its conditions and resources were concerned. The nearly completed botanical

* In biblical Hebrew, "Negev" stands for "South" but the word stems from the root "to dry", and actually means "dry place" or "desert".

survey of the Negev has yielded important scientific data regarding the composition of its flora, its phytosociology and phytogeography. The results of this pure research provided the basis for detailed investigation of the economic possibilities of the local desert species. Particularly valuable information was obtained regarding species of potential value for pasture, industry, medicine, soil conservation, etc. The basic botanical studies have likewise paved the way for the practical survey of the pasture potential of the various desert plant communities.

The soil survey provided a stepping stone to the classification, assessment, and evaluation of the arable soils of the desert. Similarly, the hydrological survey is continuously yielding information regarding available groundwater resources and their utilization. The climatological survey has been of invaluable importance for various practical research projects such as artificial rain, utilization of rain water for desert irrigation, siting of experimental machinery for the utilization of wind energy, etc.

A good example of the merging of the three types of research comes from the work on dew. Basic research on the quantitative estimation of dew was crowned with success. This research remained of purely scientific value, until the discovery was made that the aerial parts of plants are capable of taking up water from the air in the form of dew. Then followed a country-wide survey of dew, which should eventually enable the mapping of areas where dew is available in amounts which could be profitably utilized by plants. The next step leads to the extremely practical research on providing crops with artificial dew irrigation (particularly at night), thereby conserving large amounts of water. However, before this can be undertaken, some purely physiological work, now under way, will have to be completed.

A great volume of work has been done on the water-balance of plants, and on the plant-soil water relationships under desert conditions. The information obtained has been of great value for basic research. It has taught us a great deal regarding the methods of water economy employed by various desert plants, and has offered the means for a re-evaluation of various concepts of water balance in general, and of desert plants in particular. On the practical side, it has provided us with a basis for the correct assessment of water requirements of various crops under different soil and climatic conditions prevailing in the desert.

Another basic research of this type was carried out on the regulation of germination in seeds of desert plants. The interpretation of the results in terms of ecology and plant distribution in the desert is of a purely scientific interest. However, since the work concerned itself mostly with species of economic importance, the results had a marked practical significance, inasmuch as they were instrumental in the reseeding work which was carried out in the Negev. Applied research based on these results has led to improved methods for increasing germination and emergence percentages in the field, and in hastening sprouting. As a corollary to these germination studies, researches have been launched on physiological and agrotechnical aspects of reseeding under the climatic and edaphic conditions particular to the desert.

Other methods of propagation are also being investigated under field conditions, in the nursery, and in the laboratory.

The noxious weeds and useless perennials which make their appearance wherever parched soil is irrigated and cultivated have now become a major problem. This has promoted research in their chemical, physical and biological control.

Archaeological and geographical investigations which were carried out in the Negev, have proved conclusively that its ancient inhabitants had developed an advanced form of desert agriculture, based upon local flash flood water. This immediately transformed the pure research into an applied one, and hydrologists, soil conservationists, botanists and agronomists, were added to the archaeological-geographical research team. Also, an intensive study of surface runoff, which is the cause of such flash floods, has been planned for the main catchment basins of the Negev. The results so far achieved in the studies of the ancient flash flood irrigation practices fully justify an intensification of the efforts. These results, in combination with advanced methods of irrigation engineering, have already been applied with considerable success to present-day flood-water spreading and soil conservation practices. It is hoped that the research will be extended to include work with scale models of catchment basins, so that some of the major problems might find their answer through laboratory work.

The success of the work on reseeding and water spreading has stimulated interest in desert pastures. Routine investigations are in progress on the carrying capacity and nutritional value of the various pasture types found in the

desert in different seasons. Research on pasture regeneration under various conditions of grazing, by different animals, and in different seasons, has been planned. Experiments designed to improve pasture by application of fertilizers and manure, by addition of legumes and pasture-shrubs, and by elimination of undesirable species, are also under way. In this connection mention must be made of the work being done on the drought resistance of various ecotypes of pasture plants, which is to be integrated with genetic studies and work on plant breeding.

Studies are also being made on the place of woody species of plants in desert economy. The provision of shade in the hot climate is of importance to both livestock in pasture, and around human habitation. Shade providing species are being selected, introduced, and investigated under desert conditions.

The relative abundance of saline water in the desert has caused an increasing interest in special crops which are salt-tolerant, and adapted to desert conditions. Success has been met with in this respect with fibre-plants for the paper industry and with several vegetable and exotic fruit plants. In some of the oases in the Negev, where fresh water had been located, temperature and humidity conditions were found favourable for growing certain crops out of season. Further investigations along these lines are in progress. It is also planned to look into the possibility of utilizing suitable arid localities for the commercial production of ee ds of arid zone economic plants.

The conservation of water resources and the increase of water potential are of prime importance in the desert, and much effort is being diverted in this direction. A major effort is being made to find a solution of the problem of sea-water demineralization by a revolutionary and hitherto untested method. Concurrently experiments are being undertaken on physical methods for the reduction of evaporation from water reservoirs. Another aspect concerning the conservation of water has arisen from the practice of storing flash flood waters by dams, later using them for irrigation during the dry season. A more intensive utilization of these temporary reservoirs is being tested, by using them for growing fresh-water species of edible fish as long as they contain water. This also serves to enrich the irrigation water with valuable manure. Studies on the potentialities and economic possibilities of hydroponics in areas lacking adequate soil and irrigation water (desert, and barren mountainous regions) are under way.

A combination of water conservation and solar energy utilization is being tried. Cheap methods for the mass culture of algae, utilizing the strong sunlight which is available throughout most of the year, and by re-use of the culture solution have been evolved, and improvements in the existing methods are being worked out. Besides this biological method, large scale attempts to harness solar energy have been crowned with considerable success. Low pressure steam, at economic prices, is already being produced by trapped solar energy. The immediate uses to which the steam may be put, such as chemical and industrial, or for refrigeration and air-conditioning, are already being planned. Further investigations are taking place with a view to improving the system so as to produce high-pressure steam for power supply, etc. The use of such trapped solar energy in conjunction with water-demineralization projects is also being looked into, in order to reduce energy costs.

One other source of energy, especially abundant in deserts, is also being tapped. That is, wind energy. Apart from the wind survey, tests are in progress on the possibility of wind energy utilization in settlements situated at a great distance from power lines. Wind energy stored in accumulators may be used for purposes requiring constant current output, such as operation of machinery, lighting, cooking, operating railway-crossing signals, and lighthouses. It may also be used directly without storage, for processes not requiring specific timing and a constant energy output, such as water-pumping, refrigeration, etc.

A new field of investigation which is being opened up, is the physiology of work under desert conditions. The aims of these investigations are, first, to find the physiological and pathological effects of desert conditions (heat, dust, dryness, thirst, etc.) on the human body at work, and, secondly, to devise ways and means for reducing the strain they produce, combating their undesirable effects, and increasing comfort. Of a similar nature is the contemplated project of research on construction and architectural design of dwellings in the desert, aimed at achieving optimal living conditions of temperature, humidity and aeration. At the same time, the answers to problems of the durability of houses and construction materials under desert conditions might be obtained.

A major agricultural problem in the desert is the formation of crust on top of loess soil after being moistened. This causes reduced

percolation of rain and flood-water into the soil, increased runoff, and decreased germination and seedling emergence. An intensive study into the properties of this crust, coupled with work on natural and artificial soil-conditioners, is under way. When completed, this study might offer suggestions for the improvement of soil productivity and reduce the difficulties of reseeding, cultivation, erosion and flood control.

Other studies on the properties of desert soils are under way. Salinity, effects of irrigation, fertilizers, etc. are all being investigated in the various types of arable soils of the Negev.

Of a similar nature is the work being conducted on sandy soil. The gradual rehabilitation of such soils is carried out by the binding of shifting sands, re-vegetating the bound sand first with soil-forming species, then with economic plants (pasture, grain, vegetable, fruit, industrial, medicinal, etc., according to possibilities and needs).

A major move towards integrating these researches, and facilitating the immense task of their coordination, has been made. The construction of an Arid Zone Research Institute has been commenced in Beersheba. This institute will offer to all the scientific bodies working in this essential field, laboratory space, modern facilities, experimental plots, etc. Its doors will be open to scientists from abroad, interested in working on arid zone problems of regional and international value.

Participants in arid zone research in Israel

Government of Israel: Ministries of Agriculture, Development, Communications, and Prime Minister's Office.

The Jewish National Fund and Jewish Agency.

The Hebrew University of Jerusalem.

The Weizmann Institute of Science, Rehovot.

Technion—Israel Institute of Technology, Haifa.

The Beersheba Municipality.

UNESCO and FAO.

The United States of America Operations Mission in Israel.

The Ford and Rockefeller Foundations.

The desert communities: Eilat, Beer Ora, Yotvata, 'Ein Yahav, 'Ein Hatseva, Sdom, Sde Boqer, Mashabei Sade, Revivim, Kfar Yeroham.

D. KOLLER
The Research Council of Israel

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Entropy	S	Chemical potential	μ

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3. TAYLOR, G. I., 1932, *Proc. roy. Soc.*, A138, 41.

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